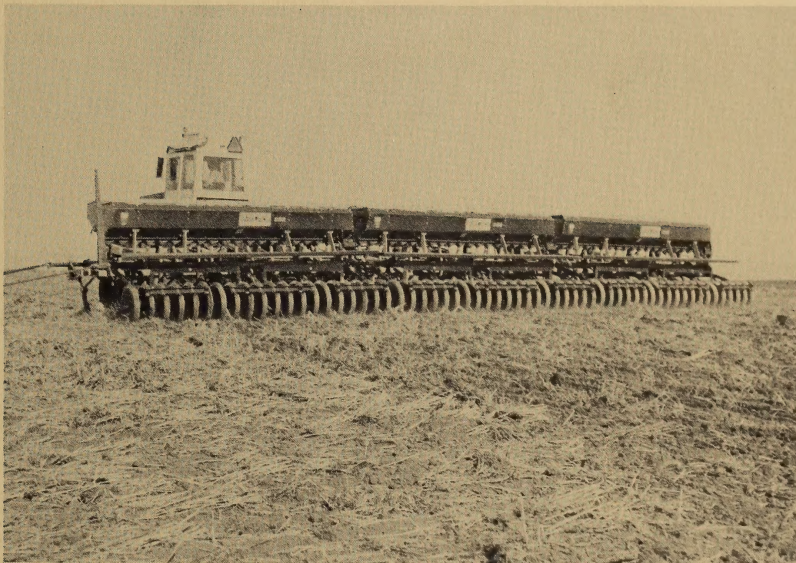


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Proceedings of Zero Tillage In-Service Training Course

July 24 & 25 1979
Calgary, Alberta

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PREFACE

Zero-tillage farming has been a topic of major interest in recent years. To convey the latest developments and to evaluate the applicability of zero-tillage to Alberta conditions, an inservice training course was held in Calgary on July 24 and 25, 1979.

This publication presents the proceedings of the course. Papers are reproduced as submitted by each rapporteur. We hope that their circulation will draw attention to the concept of zero-tillage and stimulate some thought before attempting to adapt or implement zero-tillage to farming under Alberta conditions.

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ZERO-TILLAGE IN-SERVICE TRAINING PROGRAM

Marlborough Inn, Calgary
July 24 & 25, 1979

DAY 1 - JULY 24

Chairman - Walter Yarish

8:30 A.M.	Registration & Opening Remarks	Walter Yarish (ADA - Edmonton)
9:00 A.M.	Principles & Concepts of Zero Tillage Why Zero Tillage?	Doug McBeath (CDA Lacombe)
9:20 A.M.	Zero Tillage - U.S. Point of View Techniques & Concepts that Work	Jim Krall (Professor, Montana State University)
10:15 A.M.	Coffee	
10:30 A.M.	Zero Tillage - U.S. Point of View Cont'd	
11:15 A.M.	Machinery: Availability, Modifications, Drill Selection, Fertilizer Attachments	Murray Green (ADA - Airdrie)
12:00 Noon	Luncheon	
1:15 P.M.	Melroe Seed Drill - Specifications, Costs, Availability	Jake Williams (Melroe Rep.)
1:30 P.M.	Hay Buster Seed Drill - Specifications, Costs, Availability	Vern Belsheim (Hay Buster Rep.)
1:45 P.M.	Fertilizers and Zero-Till Fertilizers placement, type and rate of application	John Harapiak (Western Co-op Fertilizers, Calgary)
2:15 P.M.	Economics as related to Zero Tillage	Lorne Owen (ADA-Lethbridge)
3:00 P.M.	Coffee	
3:15 P.M.	How to establish a zero till program - (A Step by Step Guide) - timing, land preparation, straw management	Wayne Lindwall (CDA-Lethbridge)
4:30 P.M.	Adjourn	

DAY 2 - JULY 25

8:30 A.M.	Zero tillage - European Point of View Techniques and Concepts that work	Bill Ascroft-Leigh (ICI - England)
9:30 A.M.	Weed Control under a Zero Tillage Program Herbicide mixtures, roller application of herbicide, etc.	Ashley O'Sullivan (CDA - Lacombe)
10:00 A.M.	Coffee	
10:15 A.M.	Zero Tillage - Is it the solution?	Keith Price (ADA - Edmonton)
11:00 A.M.	Provincial Research & Guidelines	Ferrin Leavitt & Adolph Goettel (ADA - Edmonton)
11:30 A.M.	Wrap-up Discussion	
12:00 Noon	Luncheon	
1:15 P.M.	Bus Tour of zero-till plots at Strathmore	Larry Welsh & Murray Green (ADA - Airdrie)
4:30 P.M.	Adjourn	

Introduction to Zero-Tillage

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Zero-tillage may be defined as a crop production system whereby a crop is seeded directly into a seedbed which has not been tilled since the harvest of the previous crop. The concept of zero-tillage is not new. Various forms of zero-tillage, no-till planting or direct drilling have been practiced in the United States and Great Britain for over 25 years. Only in recent years has the practice gained some acceptance in western Canada, although some research on zero-tillage has been underway at the Lethbridge Research Station for over a decade.

The successful production of crops using zero-tillage requires very high levels of management skills, and I expect that several speakers throughout this program will emphasize the skills and expertise required. In this presentation I shall limit myself to a discussion of several of the advantages to be gained from zero-tillage. In doing this, I do not wish to imply that there are no disadvantages. From the topics listed on the program, I am confident that other speakers will adequately describe and emphasize the disadvantages.

The advantages that have been reported for zero-tillage, not necessarily in order of importance, are enumerated below.

1. Saving of time. During the spring of the year, and to a lesser extent in the fall, much of the time of a farm operator is used for cultivation of his fields for the preparation of a seed-bed. Using a zero-tillage cropping system, these tillage operations are not performed so that less of the farmer's time is required for soil preparation. A small portion of this saving will be offset by the additional herbicide applications that may be necessary for zero-tillage, but a field sprayer will cover a field much more rapidly than a tillage implement.

2. Saving of fuel. One of the major requirements for petroleum fuels in farming operations is for tillage of the soil. Most of the fuel used for tillage in a conventional cropping system will be saved where zero-tillage is practiced. Again, a small portion of the saving will be offset by the fuel required for the additional herbicide applications that may be necessary, but much less fuel is required to operate spraying equipment than would normally be required by tillage.

3. Reduced soil erosion. Under zero tillage the crop residues are left on the soil surface and not worked into the soil to promote their decomposition. This build-up of residue will eventually result in improved structure and better aggregation of the surface soil. The improved structure, along with the presence of crop residues will reduce erosion by both wind and water.

4. Conservation of soil moisture. The soil moisture available for crop growth is conserved in several different ways in a zero-tillage system. Losses due to evaporation from the surface horizon in the spring of the year are minimized where the soil is not loosened up by cultivation. This will usually result in more soil moisture for rapid germination and early growth of the crop. It will usually mean that the crop will not have to be seeded as deeply to reach moist soil as where cultivations have been done. The infiltration of rainfall and melted snow will also be increased because of the surface residues and the improved aggregation of the surface horizon. Less moisture will be wasted during the growing season by the growth of weeds under well-managed zero-tillage. This will be discussed more fully under the next advantage listed.

5. Reduced weed growth. In well managed zero-tillage cropping systems, annual weeds have generally been found to decline. Most observers have attributed this to the fact that weed seeds have not been incorporated into the soil by cultivation, and thus have not been stimulated to germinate rapidly. In the initial few years under zero-tillage the apparent population of annual weeds may not decline as the seed already in the soil germinates, but in later years the number of annual weeds usually declines as the weed seeds produced are not mixed into the soil. The opposite effect is often observed where perennial weeds are present in a field under zero tillage. Perennial weeds such as Canada thistle, sow thistle, quack grass and toadflax spread rapidly by means of underground stems or rhizomes. Apart from the use of certain herbicides, intensive cultivation is a very effective means of keeping these weeds under control. Under zero-tillage, this method of control is not available and these weeds usually tend to spread and increase in density. Effective use of herbicides such as glyphosate is required to control these perennials.

6. Reduced capital investment. The total investment required for the farm operation is reduced since plows, cultivators and discs need not be retained for a zero-tillage system of cropping. These savings are partially offset by the generally higher cost of zero-tillage drills and the need for a high quality and accurate sprayer for herbicide application. In addition to the investment savings on machinery, there may also be some savings in operational costs through lower repair and maintenance costs on the machinery retained.

7. Increased yields. The adaption of zero-tillage has usually, but not always, resulted in increased crop yields. Most observers have attributed these yield increases to the greater amounts of soil moisture that are available to crops under zero-tillage. As mentioned previously, this extra moisture may originate from the increased infiltration of rain and snow melt, and from the decreased evaporation of moisture in the surface soil in the spring. Increased yields have also been attributed to earlier seeding in the spring that is sometimes possible under zero-tillage.

8. Better support of harvest machinery. In some parts of the world it has been noted that the soil under a zero-tillage cropping system is much firmer at harvest time than fields which had been plowed, and consequently the fields provide much better support of the heavy harvest machinery. In most parts of western Canada this is not seen as a major advantage.

9. Uniform snow distribution. The presence of standing stubble during the winter months has resulted in more uniform entrapment of snow on zero-tillage fields. This contributes to both reduced soil erosion, primarily wind erosion, and to more uniform availability of moisture for crop growth the following summer.

10. Decreased soil salinity. The practice of zero-tillage, along with continuous cropping and a reduction in the amount of land in summerfallow, can contribute to a reduction in the spread of soil salinity by ensuring that as much moisture as possible is utilized for crop growth. In areas where summerfallow may contribute to saline seep and soil salinity, the introduction of zero-tillage along with other practices could assist in solving some of the problems associated with soil salinity.

In looking back over all the reported advantages of zero-tillage, it might serve some purpose to speculate a little on the relative importance of these advantages. If such speculation serves only to stimulate discussion within this group it may contribute to the success of this meeting. I have already indicated where I feel that some of the above advantages are of relatively little importance in western Canada. I would like to propose that the single most important advantage of zero-tillage is its contribution to soil conservation. The potential reductions in both wind and water erosion that can be gained from zero-tillage are long term benefits which probably outweigh all the other possible advantages combined. Second in importance, I would rank the conservation of soil moisture, and I consider this benefit to be of great importance in drier parts of western Canada, particularly in the dark brown and brown soil zones. The remaining advantages, while important, are of much less long term benefit to the agricultural industry in western Canada.

Any questions, disagreement or discussion generated by these remarks will be most welcome.

ZERO TILLAGE - U.S. POINT OF VIEW

by
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Most agriculturists in the Great Plains agree that we have not developed a permanent cultural practice for the Great Plains. Though crop-fallow, the predominant system prevalent for the past 40 years has been successful, it is doubtful that this practice can continue, for in time it will deplete our soil resource. Fallowing makes the land subject to wind and water erosion, is creating saline seep, and polluting our streams. Employing no-till practices are an advancement in the conservation of our vital resources.

The Great Plains of America, once known as the "Great American Desert" is a region of extremes in climate. The zone is generally characterized by long cold winters, cool or cold soils, short growing seasons, evapotranspiration rates that exceed precipitation, low relative humidity, and hot days followed by cool nights. The precipitation is varied. One year it may be less than six inches (15 cm) and the next year it may be over 20 inches (50 cm). Fortunately, most of the precipitation occurs from April through June when crops are in their most productive stage. Associated with the above are the winds that often become high, especially in the fall and spring. Along the eastern slope of the Rocky Mountains

there occurs areas which received frequent chinooks (warm winds) which melt the snow cover creating extensive runoff and extremes in temperatures. These climatic factors coupled with variable soils in the glacial till make the development of dryland cropping systems difficult.

One of the difficulties in researching cultural practices is portraying average yields. Presently most data reports combined or harvested yield. One can only question this method of reporting when fallow has been employed, for with a crop-fallow rotation it requires twice the amount of land to produce the one harvested crop. Thus the yield should be divided by two. However this is not realistic since the amount of land to be seeded and harvested is doubled. A realistic figure is a need for comparisons. Recently at a Cropping Systems meeting in Montana it was agreed that whenever a recropping yield was 65 percent of fallow it was economically equal to it. In time we will undoubtedly devise a more accurate means for reporting yields.

Considerable data has been generated the past several years on some aspect of no-till or zero-till. Our endeavors have been primarily on the recropping aspect of no-till. The data presented hereafter are only summaries of typical results. For more detailed information the reader should contact the author for the sources of information.

Management Requirements for No-Till Recropping

No-till or zero-till planting of crops directly into standing stubble should be successful and have several advantages over conventional tilled seedbed preparation:

1. Evaporation should be reduced as the soil is not disturbed as much.
2. Shattered grain and weed seeds on the surface would not be worked into the soil, thus less of a problem.
3. Dormant weed seeds deep within the soil would not be surfaced to germinate.
4. The stubble would be left standing for snow trapping.
5. Less energy would be required.

For successful no-till recropping, three factors are important:

1. Complete vegetation control, pre-planting as well as post-emergence.
2. An adequate fertility program, based on soil tests.
3. A drill or planter capable of planting through heavy residues and capable of depositing the seed into the soil.

Inadequate attention to any of the three factors above, regardless of moisture supply, can lead only to disaster.

An experiment conducted with recropped barley at Huntley, Montana in 1974 demonstrates the necessity of the above three factors. Vegetation control, volunteer and weeds, prior to planting, was obtained with glyphosate and after the crop emerged with post-emergent 2,4-D. Fertility levels were maintained by the application of Nitrogen at 30 lb/a. All plots were planted with a no-till drill using coulters, double disks and press wheels. For drill comparisons a conventional end wheel double disk drill was employed adjacent to the experiment using the same vegetation control, and fertility level. A summary of the results are as follows:

	Stubble Type	Vegetation Control Pre	Control Post	Fertilizer Use	No-till Drill	Barley Yield Kg/ha
1.	Barley	0	X	0	X	968
2.	Barley	0	X	X	X	1,079
3.	Barley	X	X	X	X	1,261
4.	Barley	0	0	0	X	weeds
5.	W. Wht	0	X	0	X	991 (10% Wht.)
6.	W. Wht	0	X	X	X	700 (100% Wht.)
7.	W. Wht	X	X	X	X	951
8.	W. Wht	0	0	0	X	weeds
9.	Barley	X	X	X	0	No stand
10.	W. Wht	X	X	X	0	No stand

From this table it can be seen that treatments three and seven were the only cropping methods that produced a satisfactory yield of planted grain. Of interest is treatment six, no barley was produced; however the control of post-emergence weeds and fertilizer did produce a satisfactory crop of volunteer winter wheat. The failure of farm operators to manage all three of the above factors is the chief cause of recropping failures.

Summer Fallow, The Good, The Bad And the Ugly

Compared to annual cropping, the biannual system of culture, which employs fallowing, has several advantages:

1. It generally leaves a reserve moisture supply which reduces the risk of crop failure.
2. It is a means of weed and volunteer control.
3. It allows for a long period of time to prepare an ideal seedbed.
4. The organic matter is broken down and nitrification occurs.
5. When properly tilled, moisture is usually near the surface facilitating the emergence of fallow-sown grain.

There may be other advantages to fallow. Probably the main reason for continuation of the system is No. 1 above, reducing the chance of failure.

The crop-fallow system has several not-so-good attributes.

1. The system does not use precipitation efficiently, water is lost through a deep percolation and evaporation.
2. It has generated numerous weeds that are adapted to the cycle. Cheatgrass (*bronus tectorum*) would be the most predominant.
3. Considerable energy is required for fallowing.
4. The crop residues after fallow are much greater making recropping difficult.

5. As the land is bare 50 percent of the time solar energy is not totally utilized.
6. The ambient temperatures over bare fallow fluctuate considerably, thus causing fall-sown crops to winter kill.

There is an ugly side to the crop-fallow system.

1. In spite of strip cropping, wind erosion occurs.
2. Water erosion is enhanced, especially during heavy rainstorms and during snow melt.
3. The chief source of non-point pollution of streams is fallowed or bare land.
4. During seasons of more than adequate precipitation, unused soil water in fallow moves downward creating saline seep and degradation of our underground water.

Unless these extremely harmful effects of fallow are checked our soil will soon be non-productive.

Methods of No-Till Planting

When comparing no-till planting with conventional or other methods the results are varied. Evidently, success is dependent on soil type and moisture condition, straw amounts and moisture content, occurrence of precipitation after seeding and several other factors at Huntley from 1975-77. A planting method study, given below, shows that winter wheat did not yield as well as conventional till plant. No differences were encountered with spring wheat or barley.

Method of Planting

Huntley, MT 1953 to 1957, Kg/ha

	Winter Wheat	Spring Wheat	Barley
No-till	2266	1331	1732
Till Plant	2363	1345	1722
2,4-D Check*	1958	1146	1395
Fallow	2951	1569	2082
Fallow 65%	1918	1020	1353

*No-till seeded, only part emergant weed control.

Using the 65 percent value for fallow shows that recropping regardless of planting method is superior to fallow.

In eastern Montana (Sidney) a test in 1978 with spring wheat shows conventional till and seed to be better than no-till.

No-till*	Till Plant	Fallow	65%
1665	2355	2929	1903

*Yields - Kg/ha

Wild oats, pigeongrass and cereal disease were cited as the cause for reduction in yields.

A recent summation of trials conducted in the Triangle Area of Montana (north of Great Falls) from 1974 through 1978 comparing no-till vs. till shows a substantial benefit in no-till.

	No. Locations	<u>Kg/ha</u> No-Till	<u>Till-Plant</u>
W. Wht	8	1827	1375
Sp. Wht.	20	1177	1131
Barley	18	<u>1436</u>	<u>1316</u>
	Average	1480	1274

*Location X years X trials

An increase of 206 kg/ha was realized from no-till compared to tilling than planting over the five-year period.

Effect of Previous Crop on No-Till Yields

To determine the effect the previous crop had on the succeeding crop when no-till recropped, a three-year study was conducted at Huntley, Montana where various stubble types were obtained from crops grown on fallowed land the previous year. Winter wheat, spring wheat and barley were no-till planted across these stubble types at fall planting and the following spring. For comparison a fallow strip adjacent to the stubble strips was simultaneously planted. The yields in Kg/ha are given below:

Planted Crop	No-tilled - Previous Crop			Fallow	
	Sp. Wht.	Barley	W. Wht.	Field Yield	65%
W. Wht.	2037	2689	1865	2951	1918
Sp. Wht.	1290	1322	1179	1513	993
Barley	<u>1608</u>	<u>1909</u>	<u>1350</u>	<u>2082</u>	<u>1353</u>
	1645	1973	1464	2182	1421

Krall, Huntley 1975-77, Avg. three reps.

When using the breaking point of 65 percent of the field or harvested yield all of the no-till crops yielded more than fallow. The planted winter wheat, spring wheat and barley yielded the most on barley ground followed by winter wheat and spring wheat. The recropped spring wheat yield was the lowest. This same trend has been noted in other trials.

Flexible Cropping

Recently a new concept for dryland cropping has been advanced, known as the flexible cropping system, or dryland cropping strategies. It casts aside the fixed pattern associated with crop fallow or any "locked-in" rotation. It is based on soil moisture in the stubble at seeding time and closely fits the variable weather pattern associated with the Great Plains.

The key to the system is to probe the soil for moisture at seeding and then make a decision whether to summerfallow or recrop. In general, medium clay soils will hold two inches (5 cm) of soil water for every foot (30.5 cm) in depth. Research and experience has shown that it requires nearly four

inches (10 cm) of soil water to establish a crop. Thus it would require 24 inches (61 cm) of soil moisture to start the crop. The final yield thereafter would be based on seasonal precipitation. For fall sown grains eight to 10 inches would be adequate.

To best explain the flexible system based on time an example is given where it is compared to alternate fallow and other systems.

Crop Year	1	2	3	4	5	6	7	8	9
Moisture Depth	<u>28"</u>	<u>36"</u>	<u>14"</u>	<u>18"</u>	<u>38"</u>	<u>42"</u>	<u>56"</u>	<u>6"</u>	<u>32"</u>
Crop-Fallow	C	F	C	F	C	F	C	F	C
3-Year Rotation	C	C	F	C	C	F	C	C	F
Cont. Cropping	C	C	"c"	"c"	C	C	C	"c"	C
Flexible Cropping	C	C	F	C	C	C	C	F	C

"c" designates possible failure.

The moisture depths in stubble shown to a large degree are similar to the amounts encountered during the past five years. It varies from six to 56 inches and is rarely the same each year. Under the ridged alternate fallow system, using the 24 inch guideline, the land would be fallowed four years out of nine. Two years when there was adequate moisture for recropping, years two and six, it is during these years when water is added to the recharge creating saline seep.

The three-year rotation, using fallow once every three years, too, does not fit the random moisture pattern. During the first three years it fits well since adequate moisture is present. However, during the remaining cycles the rotation does not fit the soil moisture pattern.

With a continuous cropping system the chances of failure ("c") is pretty good during years three, four and eight. In spite of this six reasonable crops could be expected in nine years. This system would totally shut off the recharge and is recommended on saline seep recharge areas and soils that are rocky, sandy, or too shallow to hold no more than three inches of water.

The flexible system is based solely on moisture supply, plant if over 24 inches. Since two years of fallow is not satisfactory, the land would be cropped in year four as it was fallowed the year before. Thus, only two fallow years would result out of nine years. Under this system the crops would have to be rotated between fall sown crops, alternate crops, and spring sown cereals to avoid diseases and other pests.

Remember this is only a hypothetical solution for cropping the Great Plains. Keep in mind though that it is:

1. Flexible
2. Uses all the water
3. Saves energy
4. Avoid degradation of the land by erosion and salinity

Energy Requirements for Cropping Systems

With the shortage of fossil fuels cropping systems have to be devised that will reduce the requirements. Recent data published by North Dakota on gasoline requirements is given below for various farm operations.

Gasoline Requirements - Farm Operations
U.S. Gallons/Acre

Moldboard or Disc Plow	3.14	Grain Drill	.23
Chisel Plow	1.67	Spike Harrow	.13
One-Way	.95	Swather	.34
Tandem Disc	1.04	Combine	1.07
Noble Blade	1.50	Sprayer	.09

(North Dakota Exp. Sta. Bull. 493)

The above information shows that considerable fuel savings could result, especially those implements that use considerable fuel are used less frequently.

Similar results have been reported by Wyoming. Estimated energy requirements for various systems and energy required per unit of wheat were obtained from six years of cropping at the Sheridan Substation. Their finds are given below:

	Kw-h/ha	Kw-h/m ³
W. Wht.-Fal.	689	293
Sp. Wht.-Fal.	784	363
W. Wht-S. Wht-Fal.	512	271
Cont. No-till W. Wht	254	194
Cont. No-till S. Wht	356	294

(ASAE Paper No. 78-1516)

These data take into account all the aspects of production including the energy requirements for herbicides. This information certainly indicates that if the Northern Plains' farmer could successfully continuously crop the land they could reduce the energy requirement by 1/2 to 2/3 the amount used today with the crop-fallow system.

Evaluation of No-Till Seeding Methods

Tests were conducted from 1973 to 1977 at four locations in Montana to evaluate basic drill components for seeding into heavy small grain stubble. Basic components included rolling coulters, furrow openers, and press wheels. Performance ratings were based on the ability to cut through the stubble, amount of soil moved between the rows, and straw bunching, which created plugging. Emergence stands were considered to be more important than final yield since it was noted that volunteer plants occurring between the row had altered the yield. A summary of the performance and emergence or stand is given below:

		Ratings *		
	Cut Stubble	Soil Mov.	Bunch, Plug	Emergence
<u>Coulters</u>				
With coulters	1.4	1.7	1.3	1.7
No coulters	2.4	2.0	2.3	1.5
<u>Openers</u>				
Double disk	1.3	1.3	1.2	2.4
John Deere HZ	1.9	1.8	2.0	2.0
Spear Point	2.3	2.3	2.2	1.5
Four inch shovel	2.7	3.0	2.7	1.8
<u>Press Wheels</u>				
Round Rubber	1.6	1.6	1.6	2.5
Ribbed tire	1.5	1.6	1.4	2.3
Steel V Wheel	1.6	1.8	1.5	2.6

*Rating 1 good to 3 poor for performance

These studies show that coulters are necessary in heavy trash and that the type of openers had more effect on the combination performance than coulters or press wheels. The double disk, then the John Deere spear point, both being narrow, performed better than the shovel type openers.

Double disking, undercutting with a blade or most tillage operations tended to make seeding more difficult for the stubble, was dislodged and did not function as a "comb" to keep the trash moving past the openers. The only combination that did not plug in tilled stubble was a straight coulter followed by a double disk. Shank-type openers soon plugged in tilled stubble.

Differences in stand counts and volunteer counts were obtained from double disk and four inch shovels as follows:

	Stand Counts per foot of seeded row		Volunteer Plants per foot between rows	
	Double Disk	4" shovel	Double Disk	4" shovel
Average	21.8	17.8	8.3	17.0

At Conrad, Montana winter wheat was sown into standing and double disked barley stubble in 1977. Considerable volunteer barley resulted due to late emergence of the winter wheat. The harvested winter wheat contained considerable amounts of barley. The barley was hand separated after harvesting and the percent recorded. These average percentages for the two extremes, namely the shovel openers and double disk, are given below:

Stubble Treatment	4" Shovels		Double Disk	
	No-Till	Disked	No-Till	Disked
Average	58.6%	80%	27.5%	56.8%
Average of both	69.3%		47.2%	

All of the harvested grain would have been sold on the market as feed, due to mixtures. The no-till system sown with a double disk was far superior to disked stubble sown with a four inch shovel. These high percentages of mixtures due to volunteer made the yield results worthless for no significant differences were found for any of the treatments. This same effect was noted in most seeding trials.

Seedling Stunt

For several seasons with most no-till crops, especially on winter wheat stubble, it has been observed that the plants were dwarfed, did not tiller, and produced short heads in the area where the chaff was deposited behind at the harvest. This same effect was noted many years ago on stubble mulch fallow. More recently the symptoms have been reported on chemical fallow. This phenomenon has been labeled "seedling stunt".

Efforts to correct this disease by increasing fertility levels have not helped. Plant pathologists have a hypothesis that an unknown soil fungi is creating a substance known as patulin that inhibits the tillering and stunts the plant.

Recent innovations to facilitate recropping

Frost seeding - as the term implies, frost seeding is planting grains with an ordinary disk drill in early spring, after the snow is gone. The soil usually is thawed to a great depth, but later there occurs a period of sufficient frost to support the tractor and maintain traction. This

approach to seeding has been more satisfactory when no-tilled into stubble than on bare fallow.

At Huntley this approach to seeding has produced barley crops 10 days earlier, had less weeds, and produced 471 kg/ha more grain. In central Montana in 1977 frost seeded barley averaged 1707 kg/ha compared to 1647 kg/ha for normal seeding dates.

It has been found that frost seeding cannot be accomplished every year. In 1978 and again in 1979 the soil moisture near the surface was too high resulting in a "glassy" surface or too hard to be penetrated by a double disk opener.

Earlier harvest methods - With a reduction of the number of acres of fallow, more land will have to be harvested. To spread this workload over a longer period, combining a high moisture grain should be considered. Considerable information has been generated on high moisture grains, thus it will not be covered in detail, only to say that harvesting can be started from 10 to 14 days earlier.

Another approach would be to ensile a portion of the crop as barley head-chop. Barley head-chop can be defined as grain that is cut near 40 percent moisture at a height comparable to a combine sickle bar or about 1/3 to 1/2 of the plant. Harvesting is accomplished with a forage harvester, direct cut, and ensiled. The net result is about 50 percent grain and 50 percent straw parts.

MACHINERY REQUIREMENTS FOR A ZERO TILLAGE CROP PRODUCTION SYSTEM

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As the definition "Zero Tillage" implies, there is no requirement for equipment to manipulate the soil other than to place the seeds and fertilizer in a seed bed. As the high power requirements to pull tillage equipment are eliminated, a slight reduction in tractor size may be possible. Power requirements may still remain high if larger widths of heavy zero till drills are used or if tillage remains a back up solution in case the zero tillage system should fail. The windrowing and harvesting equipment does not change between traditional and zero tillage systems unless the number of acres seeded each year changes. Management of harvest aftermath (straw and chaff) will be discussed later.

The most important management decisions in a zero tillage system will deal with weed control. Early identification of weeds and then selection and proper timing of application of herbicides is critical to satisfactory yields. There is no doubt that better results from herbicide use could be achieved by more attention to application methods and equipment.

Assuming the necessary chemicals are available to control the weeds and volunteer grain, under zero till conditions, the field sprayer could make or break the system. As written in many selected publications on sprayers, uniform spray patterns, adequate pump volume, chemical agitation, calibration, etc. must all be correct. Under zero tillage, some chemicals will perform best at higher water rates such as two hundred liters per hectare, so higher volume pumps may be required. Also, the variety of chemicals encountered can safely be handled in non-corrosive tanks such as

polyethylene, fiberglass or stainless steel. A variety of plant heights are encountered in spring spraying or during chemical summerfallow. Uniform spray coverage must be attained on all weeds so boom height adjustments must be high enough to cover the tallest weeds. The installation and calibration of 110 degree nozzle tips on the standard spacing of 50 cm and set at a height of 50 cm above the average height of the weeds, will reduce the problem of spray coverage and varying weed heights. The use of a dye or foam marker helps ensure complete overlaps. A sprayer miss will be evident throughout the crop year and in the case of perennial weeds, for years to come. The foam marker is easiest to see and line up with but disappears quickly in dry or windy conditions. It is good for fast moving spray equipment such as floaters, spray coups or trucks. The dye markers leave colors which remain visible for longer and are good for all types of sprayers. Very bright (yellow, orange) or dark contrasting colors are best on stubble which will account for 75 per cent of the sprayed acreage. Finally a sprayer monitor and a digital speedometer will help achieve consistent chemical application rates.

Under some zero tillage conditions, the standard double disc or hoe drills will successfully plant the crop. More severe conditions of heavy straw cover from the previous crops, dense soil in the surface and seed bed areas, and wet soil surfaces, especially in heavy soils require special heavier duty zero till drills.

The straw from 2.5 tons per hectare of wheat will generally not clear through a hoe drill or will cause double disc openers to roll on the surface (continuous cropping). Some systems are required to either cut or remove the straw in front of the opener. At present a rolling disc coulter

is the only system to accomplish this. One system uses only a double disc opener with enough pressure to either cut the straw or press it into the ground which can happen if shallow seed placement is desired.

Loamy soils or heavy clay soils which haven't been travelled on by equipment, are usually not a problem for seeding equipment. A clay loam soil, specifically about 40 per cent sand and 30 per cent each of silt and clay, seems to consolidate quite firmly to a depth of 30-50 mm. A great deal of pressure is required to force a double disc or hoe into this soil type. This extra weight is usually provided in the special zero tillage drills but isn't built into standard equipment. Care must be taken in adding ballast to conventional drills so that the structural strength of the drill components is not exceeded. Rolling coulters can be installed on standard drills to cut the straw and allow penetration of the double disc or hoe.

Wet and/or heavy clay soils do not scour well so soil tends to stick to rolling disc equipment and result in totally tilled ground surfaces (not desirable in zero tillage). Soil sticking to hoes leads to poor seed placement and problems in furrow closure. These problems cause the operator to run the equipment too shallow for good seed placement. It is important that packers be used to ensure the furrow is closed and firm the soil to prevent drying around the seed. From the previous discussion it would appear an acceptable zero till drill does not exist; which is exactly the case. The Haybuster, the Noble hoe drill and the Melroe Bettinson are the closest to zero till drills available in Alberta.

There are three alternatives presently available for fertilizer application under a zero tillage system. Fertilizer (liquid or granular) may be placed with the seed at seeding time up to the limits recommended by agrologists (limits for nitrogen with cereals may be 20-40 per cent higher due to better soil moisture conditions in the seed bed with zero till). Extra fertilizer can be broadcast and leached into the root zone by rain or snow. There are arguments about the economic feasibility of this technique. Finally the zero till drill can be used in the fall to band the fertilizer in the root zone where it will be available to the crop the following spring. There is considerable data to support this method of fertilizer application. This possibility treads slightly on the boundaries of the definition of zero tillage, but as better zero till drills are developed, there should be little concern about the extra soil disturbance. In the future, again only if satisfactory equipment is developed, the option of side banding the fertilizer at the optimum distance from the seed will be possible. Oilseed crops are known to respond well to this method. Two limitations stand in the way of side banding. One is excessive soil disturbance and subsequent encouragement of weed growth, and a second is the amount of fertilizer the farmer is prepared to handle at seeding time.

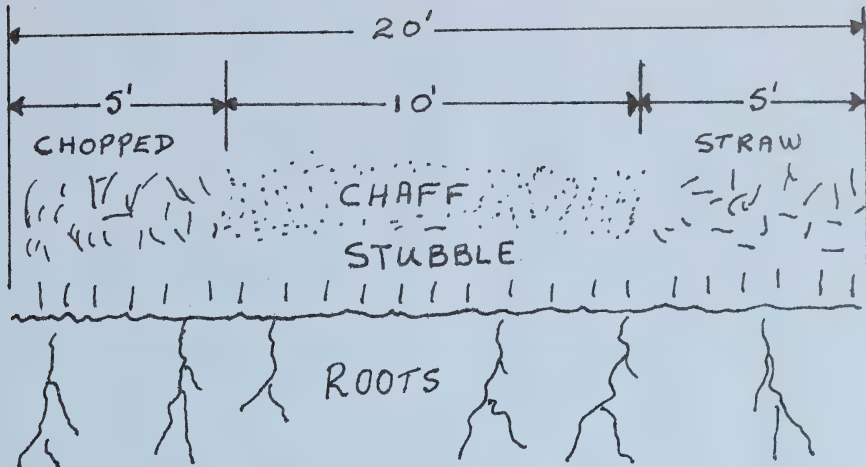
Both side banding and fall direct band application of fertilizer have some possibilities for using anhydrous ammonia as the source of nitrogen. If the zero till drill ground openers can be made to operate deep enough and packers used to close and firm the furrow, there would be little loss of ammonia. Phosphorus and other elements would have to be placed with the seed in the spring. This method will be considered in the future.

Uneven distribution of harvest aftermath, both long straw (chopped) and chaff will cause the following problems in zero tillage; varying nutrient and organic matter content of the soil, high soil moisture content under the straw, low moisture where the surface is bare, low soil temperatures (3-5 c. lower) under straw rows and therefore slow emergence of wild oats in the spring and also the subsequent crop, varying soil density due to soil moisture differences and therefore varying seeding depths of the grain drill, concentration of weeds or volunteer crops which compete with the crop, the extra insulation of the soil surface under straw rows could affect the soil microbiology, and heavy straw concentrations severely limits grain drill performance. It is not difficult to see that straw residues management is very important.

The best time to obtain even distribution of harvest aftermath is directly from the combine. Wide combine headers or windrows made from twenty to fifty foot swaths make a difficult job of putting the straw and chaff back from where it was originally taken. The most significant increase in the spread of straw from the combine chopper will result from modifying the straw chopper deflector vanes. Increasing their length to 50 cm and depth to 20 cm as well as bending them to deflect straw to the sides will double the spreading width on most commercial choppers. This angle of the straw leaving the chopper should be horizontal to ten degrees above horizontal. Too much elevation will cause the straw spread to be adversely affected by moderate winds. A slight concave dish to the deflectors helps to keep the straw airborne longer. To eliminate the rowing effect the outer ends of the deflectors should be rounded. It is unwise from performance, maintenance and safety views to increase the spread of a chopper. New designs are coming which may spread straw up to sixty feet.

The chaff and weed seeds from the cleaning shoe may contribute 20-60 per cent of the harvest aftermath. Until now this has been concentrated in a band only as wide as the combine, which is one fifth to one quarter the width of the original swath. Consideration must be given to increasing the chaff spread. Several alternatives are available: a pan type spreader placed in the chaff stream could double the spread width. There need not be any straw from the chopper placed where the chaff is spread. Another option could be installation of a chaff saver and let the chaff discharge from the blower spout. Small deflectors and the wind from the blower would spread the chaff back over the swath. This could be a bit dusty in strong winds and a problem for trucks moving up on combines. Chaff may also be elevated and dumped into the chopper for distribution with the straw. In the last two cases even distribution of the straw across the full swath width is necessary.

An example of the pan spreader behind the shoe follows: A twenty foot swath width and five foot combine body. The roots and stubble are constant across the width of the swath. Assume the straw from the straw walkers or rotor and the chaff from the sieves are equal in weight. The pan spreader doubles the width of spread of chaff from five feet to ten feet and therefore covers half the original swath. The chopper deflectors must then spread the straw to the outer five feet of the original twenty foot swath. Modified choppers tend to do that anyway. A good distribution of organic matter results.



In some situations it may be advantageous to remove the straw or the chaff for use in livestock enterprises. In this situation the remaining residue must be spread uniformly. A light harrowing to redistribute straw may be necessary. The harrows should be set to minimize soil disturbance.

It is unlikely a reduction in capital requirements for equipment will be realized by the farmer for several years after commencement of the zero tillage program. In fact, conditions may necessitate a heavier grain drill, designed for both zero tillage and traditionally cultivated fields. Most tillage equipment, especially the trash conserving type will be retained in case problems arise in the zero tillage program which can only be solved by minimum amounts of tillage. Finally, and hopefully, the extra moisture conserved by zero tillage will cause better yields and make recropping feasible, resulting in investment in more harvesting capacity.

MELROE ZERO-TILL SEED DRILL

Jake Williams
Melroe Rep.
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Melroe started importing the 702-30 Drill about 5 years ago from England from the Bettison Manufacturing Company - it has been used for many years in other parts of the world for a pasture and no-till drill and marketed under the Bettison 3-D Drill label.

As I understand it - it was primarily designed as a pasture drill - but as the advent of zero tillage came into these other countries it found a place in that application.

We have found our biggest markets for this drill in the Eastern-Mid West States - where beans and similar crops are their main stay crops.

As for Alberta we have a number of these drills out doing some pasture renovation and in no till cereal grain, rape crops. We can really thank Wayne Lindwall from Lethbridge and Murray Green of Calgary for giving us the exposure to the public that has resulted in sales for us - as they both use Melroe Drills in the programs they are involved in. I personally thank them both as they demonstrate. I sell and sales result in commissions. The 3-D in both Melroe's and Bettison's name of the drill is for triple disc. They have a rolling coulter in front of the double disc openers that cut through the trash and make it possible for the double discs to enter into the soil and not force the stubble back into the ground

with the seed. The coulter and the openers are mounted under a 4 x 8 square frame and separated from the frame by rubber buffers that absorb the shock when running over obstructions. The top of the frame has two hydraulic cylinders that create the down pressure on the coulters and openers.

On the feed shaft there are a series of neoprene foam rollers over each feed cup that run against a plexiglass window - this type of feeding system makes it unnecessary to change anything when going from one size seed to another.

By changing the speed of the feed shaft they control the amounts that are applied - this is done by changing what they call a cassette on the end of the boxes. I personally feel this system to be superior to anything I have seen - for simplicity and accuracy there are over 90 different settings that can be changed in seconds. The drill comes in 2 different sizes 17 Run and 23 Run, it has 6 7/8" spacings - the 17 Run has a sowing width of 9.9 feet and the 23 Run 13.2 feet.

It has a split hopper the 17 Run with 2288 lbs capacity (wheat) and the 23 Run 3146 lbs again using wheat as a guide. The bare weights are 4230 lbs and 5140 respectively and a height in both cases of 4'11".

We do have a quantity of 17 Run drills available at this time at our factory and 2 - 23 Runs left. As of this A.M. we have not placed an order for 1980 drills. Prices are the main factor in our ordering as the 17 Run sells FOB Alberta for \$12,300.00 and the 23 Run for \$14,460.00 and as the dollar fluctuates these days we do not know where it will go.

Melroe has done some experimental work on their own no-till drill but as for production nothing definite at this time. It has many of the features of the Bettison drill but with packer wheels and should be quite a bit less in cost.

THE HAYBUSTER MICRO-SEEDER

by
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Haybuster Manufacturing Inc. began designing the Model 1206 Micro Seeder in 1975 and it was originally intended to be a conventional style drill with a uniform depth control system. As work was progressing on the machine, the concept of reduced or even zero tillage was being considered more and more.

It was felt then, that by redesigning certain areas of the drill and by increasing the weight of it that a substantial amount of down pressure could be obtained for the purpose of cutting into harder soils and through necessary amounts of trash. Many of the original ideas were conserved; mainly the depth control aspect and the ground driven seed metering system.

During the test period of the drill, several different ideas were tried and one of these was the third disc or coulter which was found to help somewhat for cutting into heavier trash areas, but which Haybuster decided not to employ for several reasons. One is the added cost of production as well as the fact that, unlike a double disc arrangement, a coulter is not self sharpening. It runs vertically and in a short period of time it tends to lose much of its cutting ability.

Haybuster designers were also of the opinion that too much trash inhibits germination and therefore there was little use in attempting to cut excessive amounts of straw.

The rubber packer wheel was another feature which was tried and found to be not too effective on the type of press wheel. On the Haybuster drill the packer wheel is also a gauge wheel for depth control so, unlike a conventional seed drill, this press wheel packs with a great amount of pressure. In heavier soils and damp conditions, a build up of mud on the packer wheel is experienced due to the pressure of the packer. This, along with rocks jamming between the runs due to their rigidity have in the past been our only major problem.

We have 100% eliminated the rock problem by the use of what is referred to as rock bars or rock kickers, which is simply a curved bar that is located between the runs to keep the rocks from packing in. The mud problem is something that is still being worked on and in all probability there will be a solution for it very soon.

The micro seeder can be used as a single drill unit of 12' sections or in multiples of 2, 3, or 4 in a multiplex hook-up. Haybuster offers a hitch for only two units at the present time. One of the main reasons for this is that our built in drill transport is not recommended for more than two units. Operators of multiplex hook up are forced to use either conventional drill movers or suffer with the problems associated with trying to transport more than two units with the drill's own transport system.

The transport system is put into operation by lowering the runs hydraulically to raise the rear wheels off the ground. These rear wheels are then unlocked and swiveled 90° to change the direction of travel. The stabilizer bar is then unlocked to allow the drills to trail and the operator then hooks on to a transport hitch on the end of one unit and transports his drills at a maximum speed of 10 to 15 miles per hour.

Power requirements for this type of drill varies with soil type, conditions (conventional or zero tillage) and terrain. An approximate H.P. requirement would be 70 plus for 12 feet; 105 for 24 feet, and 135-150 HP for 36 feet (most often 4WD).

One area where this drill excels is in the accuracy of seed metering. P.A.M.I. has recently published its report on the drill and they found during field tests that the variation of seeding rates from cup to cup in wheat is only 2.3% and in rape 4.8% where in each instance 15% variation is the maximum tolerance.

One reason for this is probably the ground drive system and the cluster gear style of calibration setting. Another is the cup itself. Fashioned after the Massey Ferguson discer cup, our cup is also the double run feed wheel type with a coarse side for larger seeds and a fine side for most cereals and oil seeds. Our cup, unlike the Massey Ferguson type, has a radius designed in it between the wheel and its outer flange to give a good, even feed without bunching.

Our fertilizer system is the John Deere nylon feed wheel positive feed system and is found to be quite good except for fertilizers with a dust depressant added. This agent can cause a gumming up of the feed wheels and eventually causes them to turn hard and break up.

The Haybuster drill should never be operated in a zero tillage situation without having the ballast tanks installed and filled with ballast. Each 12 foot section empty weighs approximately 5900 pounds and filled with seed fertilizer and ballast, the weight increases to about 9,500 to 10,000 pounds, giving a maximum cutting pressure of 400 pounds on each disc opener. Without ballast, the drill would begin losing cutting ability as the seed and fertilizer began to run out.

The Micro Seeder can seed almost any type of seed except straight brome grass seed. Our problem there, of course, is bridging as would be the case with most conventional seed drills. However, with a nurse crop or mixed with fertilizer this seed can also be applied.

The trash cutting ability of the model 1206 has been satisfactory for the most part as we have worked the drill in almost every possible soil condition including the Texas bermuda sod and with very good success.

We have run into instances where penetration is unsatisfactory behind the tractor wheels but this condition involves only the addition of shims above the roller bar to give the run more downward travel. These shims are placed on the runs behind the tractor wheels only.

Conditions of heavy moist trash in soft field conditions are also less than ideal for this drill. Usually, rather than to cut the trash, the disc openers push it into the soil and the seed is deposited on top of it. There usually is still some covering but the seed may not have sufficient soil contact which could inhibit germination.

I believe that Haybuster Manufacturing has succeeded to the greater extent to design and introduce to the market, a product which enables the farmer to test some zero tillage in his own conditions as well as continue to carry on his conventional seeding operations; thus lowering his machinery costs.

We realize that we do have a ways to go before the drill is perfected and that we will always be forced to contend with problems associated with marketing a multi-purpose product. This is because of compromises which have to be made in the design and because of the tremendous variety of conditions which it is supposed to work in.

I believe this drill to be better for zero tillage than conventional but with out uniform depth control system and if moisture conditions are not excessive, very good results can be had using this drill in a conventional situation.

During the last three years, we have put some 450-500 units into Canada. Our major selling areas have been pretty much Southern Manitoba, Southern Saskatchewan and Southern Alberta. Lately, however, drills have been starting to sell and acquire interest further north. We have been fortunate in that our product has, to the greater extend, been purchased by good operators who are knowledgeable about the concept of zero tillage.

There have been those who purchased the drill and because of their lack of understanding of the management involved in a zero tillage operation, have become discouraged after one year's effort and discarded their machine as well as the program.

Therefore, it is very important that interested farmers have access to as much zero till research data as is possible in all areas including equipment because without further development of the concept, the micro seeder and drills like it may not have a future; just as without the proper equipment, the zero till concept may not last long.

FERTILIZER USE IN ZERO TILL FARMING¹

By J.T. Harapiak²

There is currently a great deal of interest in the concept of zero-till farming. Some of the problems associated with crop production on untilled land that have been identified include: equipment design, weed control, residue management, residue phytotoxicity, fertilizer application, soil-water relationships, plant varieties and pest management.

The greatest research emphasis to-date has been in the area of seeding equipment and weed control as it should be for these are the two most obvious problems that need to be solved in developing a zero-till system that will work under dryland agriculture. However, as a result, at present there is very little information available on the use of fertilizers under a zero-till programme. Consequently there are very few definite answers related to this subject. Therefore, at least to some extent, we need to depend on our experience gained with fertilizer in conventional tillage systems under dryland conditions and attempt to extrapolate the results to zero-tillage systems.

¹ Presented at A.D.A. In-Service Training Course, Marlborough Inn, Calgary, July 24 - 25, 1979.

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NEED FOR RESEARCH

Without a doubt fertility is one of the key factors that made modern agriculture using conventional tillage systems productive and efficient. Farmers are only going to switch to zero-tillage systems if they can be assured they can at least remain equally as productive and efficient. At the present time, fertility management presents one of the more serious information gaps in zero-till systems.

To-date there has been a great deal of research attempting to demonstrate that zero-tillage practices have something to offer in terms of erosion control, moisture conservation and reduced energy consumption. If we believe that zero-till systems are going to become more important in the future of western Canadian farming, then perhaps some new research programmes should be initiated. It is perhaps time we went beyond simply demonstrating zero-till as a possible alternative to conventional tillage. We need to design research programmes to "fine tune" zero-till with particular emphasis on the key area of fertility management if we are going to provide answers for the production orientated zero-till farmers of tomorrow.

CURRENT FERTILIZER RECOMMENDATIONS

The proponents of zero-till concepts make light of the potential problems associated with fertilizing zero-tillage crops. Phillips and Young in "No-Tillage Farming" state that "Fertilizing no-till crops is astonishingly simple in both research plots and commercial crop fields. Adequate plant food can be made available to the roots of the no-tillage crops as effectively, more easily, with more efficient use of the farmer's time, and with fully as many economic benefits as any other tillage system."

To suggest that fertilizer placement under a no-till is no more difficult than other tillage systems is to flagrantly ignore the basics of soil fertility and the wealth of research information that indicates that particularly under dryland farming, placement of fertilizer within the moist sub-surface layer of soil will significantly enhance the uptake of the nutrients. Although consideration of placement is probably more important in the case of phosphate and potash, it is also an important factor in the efficient use of nitrogen as well as other fertilizer nutrients.

FARMER EXPERIENCE AND FERTILIZER HANDLING

The most rapidly growing source of nitrogen in western Canada is anhydrous ammonia. Many farmers prefer this source because they feel it works better than dry broadcast fertilizers. Research proves that farmers are right -- anhydrous works better but no better than dry nitrogen fertilizers similarly shanked in sub-surface bands. In other words, placement of

nitrogen is a very important factor in determining its value to a crop and can often result in a yield increase of 4-5 extra bushels/acre. Deeper placement within the soil is of greatest value in drier years and/or drier regions. With proper placement, all sources of nitrogen should be equally effective for zero-till farming. The question is whether equipment can be designed to properly apply all forms of nitrogen to meet the needs of the zero-till farmer.

Prairie research indicates that nitrogen placed directly with the seed of a crop can be effectively utilized. At the rate of 25-45 lbs N/acre an additional one to two bushels/acre of grain can be produced if the nitrogen is seed-placed rather than broadcast and incorporated. This is hardly sufficient to encourage the farmer practising conventional tillage to apply the bulk of his fertilizer at the time of seeding. However, in the case of zero-till farming, with-seed placement may be the only practical alternative based on current equipment design.

Research in Sweden indicates that nitrogen placed at about twice the depth of seeding, between the seed rows is most effective. Compared to broadcast and incorporated nitrogen, this method of placement was 20 percent more effective in moist years and 90 percent more effective in drier years. Despite these very encouraging results for side banding all of the nitrogen at the time of seeding, Swedish farmers have resisted applying all their fertilizer with the seed drill. With the much larger acreages seeded by prairie farmers, resistance to handling large volumes of fertilizer at the time of seeding would be even greater.

There is also some indication that farmers would also like to reduce the amount of phosphate fertilizers handled at seeding. Pneumatic equipment is being developed that will allow a farmer to band dry fertilizers in combination with a cultivator prior to seeding. This type of system could work very well for a farmer in a minimum till system but would require some adaptation for zero-till systems.

ZERO-TILL CONFLICT

It appears that there is a conflict developing between the trends evident in nitrogen use and the trend towards reduced or zero-tillage. At present, most of the nitrogen used on zero-till is surface broadcast. Equipment could undoubtedly be developed for side-banding more nitrogen at the time of seeding but this would result in more soil disturbance. Furthermore, in the interest of timely seeding, prairie farmers are likely to strongly resist handling all of their fertilizer requirements at the time of seeding so this would not appear to be a practical solution unless the benefits for zero-till are sufficiently larger to encourage farmers to accept some seeding delay to accomodate fertilizer application.

The trends towards reduced fertilizer handling at the time of seeding could be much more readily accomodated in a minimum-tillage system rather than in an absolute zero-till system. This conflict is more serious in the dryland farming regions of western Canada where the surface layer of soil frequently dries out than in the corn producing regions where more frequent rainfall keeps the surface layer moist and surface broadcast nutrients more readily available.

SIDE EFFECTS OF ZERO-TILLAGE

Reduced tillage will have a modifying influence on soil conditions and subsequent crop growth. The most important changes take place in the soil environment in terms of soil temperature, soil moisture relationships, rate of mineralization of crop residues, insects and disease, weed competition, soil compaction and fertilizer requirements. Several of these modifications in the soil environment particularly temperature, moisture, and rate of mineralization of crop residues will have a considerable influence on fertilizer requirements.

1. Soil Temperature: Soil temperatures under reduced tillage tend to be 3-5°C lower in early growing season compared to conventional tillage. The lower temperatures resulting from the insulating effect of unincorporated crops residues lying on the soil surface may have the effect of delaying the average seedling date of zero-tilled field. Reduced temperatures also result in the slower decomposition of crop residues resulting in a slower release of recycled plant nutrients. Lower temperatures slow root development as well as root activity and may thus influence rate of uptake of soil moisture and nutrients.
2. Soil Moisture Relationships: Under reduced tillage systems, there is generally more water stored in the soil profile at the time of seeding and seed-bed moisture conditions should be superior to those encountered under conventional tillage systems. This would allow for higher rates of fertilizer to be placed directly with the seed.

3. Fertilizer Requirements: Present day soil test recommendations were developed under conventional tillage systems and tend to underestimate the fertilizer requirements of zero-tilled crops. Reduced efficiency of broadcast nitrogen and slower mineralization of soil nitrogen undoubtedly help to explain why zero-till farmers find they need to apply more nitrogen to maintain yields. Lower temperatures and reduced root activity explain why more phosphate is required. Tillage appears to have a stimulating effect on release of all nutrients and potash in particular. Reduced tillage could result in a drop in the soil available levels of potash. Reduced soil mineralization and more frequent recropping as a result of extra stored moisture will tax the sulphur supplying power of many soils.
4. Surface Residue: Tillage facilitates seeding in that it speeds the rate at which the seed-bed warms and dries out. Tillage also eliminates or destroys much of the crop residue that can interfere with the seeding operation. Under zero-till systems crop residue or trash is left relatively undisturbed. Seeding is delayed because the seed-bed dries and warms more slowly. As well, the zero-till seed drills are expected to cut through the trash so this operation is best delayed until the surface trash is dry enough for the leading coulter to cut through it clearly. If the surface trash is damp, it may be forced into the seed-bed and act as a wick, allowing precious moisture to escape from the most important area of the surface soil. This could be extremely critical in wet springs that are followed by warm, dry weather. Fertilizer placement can also be affected because some zero-till drills attempt to side band fertilizer requirements at the time of seeding. Attempting to get all this equipment to penetrate through a heavy trash cover may be quite a challenge for these drills in a wet spring.

IMPLICATIONS FOR NITROGEN FERTILIZATION

Most of the nitrogen is now applied prior to seeding and the biggest percentage of this nitrogen is applied as anhydrous ammonia. In some cases, fields are cultivated three or four times in preparation for application of ammonia. Applicators are however being developed that can knife ammonia directly into stubble without any pre-tillage if field conditions are right. This type of operation would not be acceptable in a true zero-till system since any extra soil disturbance supposedly encourages germination of weed seed. However, in many cases in the U.S. where zero-till is now well established, fields that are considered to be zero-till often have ammonia applied to them.

The use of the "Cold-Fol" principle for applying super-cold ammonia may have a place in zero-till agriculture. However, there is no research data indicating that this approach offers any practical benefits. The fact that about 15 percent of the ammonia is in the gaseous phase and the rest vaporizes once warmed by the soil, would appear to negate any prospect for shallower placement.

Because of equipment limitations and farmer preference surface broadcast applications of dry nitrogen is probably the most common method of applying nitrogen to zero-till land. Incorporation of broadcast nitrogen is unacceptable but again when the practices of so-called zero-till farmers are examined, we find that many conduct minor tillage to facilitate incorporation of the broadcast nitrogen.

Consideration should be given to conducting a light harrowing to uniformly spread the straw following the broadcast application of nitrogen fertilizer to ensure soil-fertilizer contact. This practice may be more important when the source of nitrogen is urea and it is being broadcast in the early fall or late spring when soil temperatures are warmer.

Of the broadcast products, ammonium nitrate has proved to be most effective on zero-till. Unfortunately this product is declining in importance as a nitrogen fertilizer as a result of static or declining manufacturing capacity in a rapidly growing fertilizer market. A greater percentage of this market will therefore have to be satisfied by urea. At least in the initial years of zero-till, when broadcast directly on the soil surface in the colder months, these two products should be about equally effective. However, as surface litter or mulch accumulates after a period of years of continuous zero-till, there is potential for reduced performance from urea. It should be noted that based on discussions with some farmers, the build-up in mulch may be more imagined than real.

Based on research with forages where a heavy thatch cover often interferes with the granular fertilizer coming into contact with the soil, it can be expected that urea would only be about 85 percent as effective as nitrate. The performance of urea could be improved by a slight incorporation (eg. Harrowing) and by restricting application to late fall (preferably on snow in the drier regions) or in early spring. Application prior to rain or during a humid period might be beneficial in improving the relative performance of urea nitrogen.

As the accumulation of surface litter increases, it can be expected that the nitrogen solutions (28-0-0) would become increasingly less effective as a source of broadcast nitrogen (50-70% compared to nitrate). Solutions would however lend themselves very effectively to banding at the time of or prior to seeding.

PHOSPHATE AND POTASSIUM FERTILIZATION

Phosphorus and potassium fertilization is more important in zero-till systems than under conventional tillage. These nutrients would be most effectively utilized if applied in bands directly with or near the seed row. In fact, research data clearly indicates that under conventional tillage, broadcast applications of phosphate and potash are only 20-30% as effective as banding with or near the seed row. Broadcast applications would be even less effective in zero-till than under conventional systems where some incorporation through cultivation is possible. Farmer preference and/or current equipment limitations may make it necessary to broadcast these nutrients rather than applying them at the time of seeding. Under these conditions consideration should be given to broadcasting and incorporating a much higher than normal rate of these nutrients prior to embarking on the zero-till programme. This build up in soil fertility may help overcome problems resulting from less than ideally applied fertilizer.

PRACTICAL RECOMMENDATIONS

It would appear that under zero-till at least some of the fertilizer should be placed directly with the seed. Therefore, drills that cannot apply fertilizer with or near the seed should not be recommended.

For cereal crops, all of the phosphate and potash should be placed at the time of seeding. Furthermore, at least 25-50% of the nitrogen should be placed near the seed to help carry the crop through the early growing season or until rain can be counted on to move the broadcast nitrogen into the rooting zone. Alternately, the nitrogen should be broadcast in the late fall or very early spring.

Fertilizer application for small seeded crops such as rapeseed and flax on phosphorous and potash deficient zero-till fields poses a more serious problem. Field research results appear to suggest that these crops feed poorly on surface applied nutrients because of their rooting habits. Not enough nutrients can be applied directly with the seed for these crops without causing serious germination damage. Therefore, unless seed drills can be developed that can side band the nutrient requirements, periodic tillage of these fields will be required to incorporate the nutrient rich surface layer resulting from broadcast applications.

NUTRIENT AND pH STRATIFICATION

In many cases, fertilizer required for crops grown on zero-till fields is simple broadcast on the surface. Over a period of years this practice results in the formation of a nutrient rich layer in the top few inches in which there is a significant drop in the pH level. Irregular tillage may be required to work the nutrients into the rooting zone to provide a more favourable medium for crop growth. It is also possible that an acid surface may have an adverse effect on the germination of some crops.

RECENT RESEARCH RESULTS

Based on experience gained with fertilizer under conventional tillage systems we would predict that banding of fertilizer below the depth of seeding would be extremely beneficial compared to the accepted practice of broadcasting all of the fertilizer requirements. Until recently, there has been no research data to substantiate these claims and researchers involved in zero-till evaluations doubted fertilizer industry suggestions that fertilizer should be banded into the soil below the depth of seeding for best results. In the last year there has been some new research results collected on this subject at several locations in the Pacific northwest of the United States. The preliminary results indicate quite clearly that for spring seeded cereal crops fertilizer placed beneath the seed row of barley and wheat grown on zero-till was far superior to broadcast fertilizer. For fall seeded crops, the benefits of banding were not as large.

Research by Washington State University also indicates quite clearly that broadcast nitrogen stimulates the germination of wild oats much more than banded nitrogen. This is contrary to the expectations of zero-till researchers who suggest that fertilizer should all be broadcast since any attempt to incorporate fertilizer into the soil would result in extra soil disturbance which in turn would result in a net increase in weed growth.

THE ZERO-TILL RELIGION

One of the problems with some of the proponents of zero-till is that this manner of farming is almost a form of religion with them. There is doubt that the concepts being developed by zero-till farmers will benefit agriculture in the long run. However, change should be advocated based on scientific facts rather than emotions. There is no doubt that the development of zero-till systems of cropping will have a very significant and beneficial impact on the manner of farming in western Canada. However, we forget that much of the enthusiasm for zero-till is being generated in the areas where corn is grown and until quite recently all of this land was regularly plowed. We in the dryland region of the prairies have less to gain because few of our farmers plow their land and most have been practicing a form of conservation or minimum tillage for many years.

We also conveniently forget that zero-till farming is much easier to accomplish with corn (row space 30") than wheat (row space 6"). It has been demonstrated that wider spacing is possible for cereal crops without sacrificing yield (i.e. up to 18" for spring wheat and up to 36" for winter wheat) due to the ability of crops to tiller. Under these wider spaced rows, zero-till cropping is easier to accomplish. However, these crops would have to be straight combined and under our climatic conditions a maximum row width of 8-9 inches is required to hold swathers up from the ground. Furthermore, degree of tillage is much more common than the proponents of these systems would have us believe. For example, in many zero-tilled corn fields, anhydrous ammonia is regularly banded into the soil during the side dressing season. Would the application of anhydrous ammonia be tolerated within our definition of zero-till?

ZERO-TILL -- ACHIEVABLE GOAL?

Is zero-tillage as defined (i.e. no disturbance of the soil surface except for the purpose of seeding) a practical and achievable long term goal? Many who claim to have succeeded at zero-till farming actually conduct some tillage. Is this necessarily bad? Perhaps a system of minimal tillage may be more beneficial. Economic studies have shown that some tillage can have a marked positive effect on the economics of zero-till programme by reducing chemical costs for weed control.

Furthermore, within a minimum tillage system it is much easier to accomplish good fertilizer placement that is necessary under dryland farming to insure satisfactory returns from the fertilizer investment. In addition, minimum tillage systems have the flexibility that would allow the farmer to get the fertilizer applied prior to the key period of seeding. The need for rapid and timely seeding, increasingly higher rates of fertilizer application, ever increasing farm size and a lack of skilled help are some of the factors that have forced farmers to apply most of their fertilizer prior to the seeding operation. Zero-tillage makes it difficult to get the fertilizer applied prior to seeding without having an adverse effect on expected returns from the fertilizer investment (i.e. only practical alternative is to broadcast the fertilizer required).

It is recognized that it may be more difficult to accomplish seeding in a field that has had no tillage than in a field that has been minimum tilled. Tillage dislodges stubble because of the undercutting effect of this operation. If stubble remains attached to the soil, it acts as an anchor holding crop residue and reducing the tendency for the straw to bunch or pile-up during the seeding operation.

ZERO-TILL RESEARCH PRIORITIES

There are numerous problems still to be resolved before the farmers decide to what extent they want to adopt conservation or minimum tillage and whether they indeed will choose to eliminate tillage altogether. Whatever the final outcome, it is certain that the principals being promoted by the advocates of zero-tillage will have a great deal to do with changing the face of western Canadian agriculture as we know it today. Now is the time to initiate research on the implication of zero-till farming to fertilizer application. It would indeed be unfortunate if farmers become discouraged and stop experimenting with zero-till farming because poorly designed fertilizer programmes adversely affected farm profits. It is my feeling, that unfortunately such is the case with present zero-till research programmes as far as the more productive prairie farmer is concerned.

AN ECONOMIC EVALUATION AND COMPARISON
OF COMMERCIAL ZERO AND MINIMUM TILL
WHEAT PRODUCTION SYSTEMS
ON THE
BROWN AND DARK BROWN SOIL ZONES

by

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The potential benefits of a minimum-till or zero-till cropping system has recently stimulated a great deal of interest among Alberta farmers, agricultural researchers, and agricultural extension staff. The benefits that may result from the reduction or elimination of mechanical tillage includes the conservation of soil moisture, fuel, and labor. The disadvantages are increased chemical costs and new production problems for farmers to overcome.

The idea of a zero or minimum till cropping system is not new, as the concept has been applied commercially in some areas of the United States and Europe for several years.

However, in Alberta and Western Canada, research into zero-till and the commercial application of zero-till is relatively new. Research work into zero-tillage has been conducted at the Lethbridge Research Station, on the dark brown soil zone, since the late 1960's and at present provides the best information available for local conditions. Zero-till research in the brown, thin black, black, and grey wooded soil zones of Alberta is very limited at this time. Given the variability in soil type and climatic conditions between these different regions, research results from Lethbridge are not likely to be directly applicable. Although results are not likely to be directly applicable, they may provide useful insight into production techniques and input requirements for Northern

and Central regions.

The practicality of a commercial zero-tillage or minimum-tillage production system under Alberta conditions has received little economic analysis; this is a result of the limited amounts of physical research data, and a lack of field scale trials. This lack of complete information results in a certain amount of speculation and interpretation when applying research results to a commercial production system.

Tillage and Cropping Systems

Before proceeding further, it will be useful to define the tillage concepts discussed:

- 1) Conventional Tillage - A system where the topsoil is manipulated by mechanical means such as cultivation, blading, or disking, for summerfallow and seedbed preparation.
- 2) Minimum Tillage - The minimum soil manipulation necessary for crop production or summerfallow under existing soil and climatic conditions. Minimum tillage does not define a system of tillage, but generally refers to a system with fewer tillage operations than are conventional (Lindwall, 1978 Agricultural Canada, Report 1-15).
- 3) Zero-Tillage - Is a system whereby a crop is planted with minimum soil disturbance, directly into a seedbed left untilled since harvest of the previous crop, using chemicals for weed control where necessary. (Plant Industry, ADA 1979).

The purpose of this paper is to examine the economic practicality of various zero-till and minimum tillage commercial wheat production systems. The approach is to integrate available technical, economic, and management information into representative budgets to illustrate the economic effects of the various production alternatives. The intention of this approach is to provide a useful guide for farmers who are considering zero-till. This guide will provide an awareness of some of the factors involved, as well as an example of how to organize and evaluate the effects of zero-till production for a specific farm. This analysis is not intended to provide a general and definitive recommendation.

The underlying premise of the representative budgets is that the farm manager can overcome the production problems associated with a commercial zero-till production system and realize the same output as research experiments.

In reality, the future of zero-till or minimum till will depend on each individual farmer's evaluation, an evaluation that will include both economic and non-economic factors. This evaluation should consider the effect of zero-till on a farm's financial, production, and marketing activities. A thorough financial analysis should include estimations of total costs and returns, after tax gross margins, and cash flow. Production considerations should include timing of recommended techniques, potential disease problems, weed control requirements, fertilizer response and requirements, crop residue distribution, harvesting capacities, etc.

The marketing evaluation of a zero-till production system may include: the feasibility of including oilseeds in a zero-till system; possible effects of volunteer grains on dockage and grades; as well as marketing flexibility. By flexibility, we are referring to the farm manager's ability to increase or decrease acreages in response to changing market conditions for grains and oilseeds.

In addition to each of the above, the individual farmer should look at the overall effect of zero-till relative to quota restrictions, crop insurance, policies, available labor, and required management skills.

Some of the non-economic technical and production factors which will influence a zero-till system include: (a) relationships between yield and soil moisture, (b) soil type and annual precipitation, and (c) weed populations and potential problems such as the encroachment of grassy weeds.

Some of the short and long run economic considerations that will influence the practicality of zero-till include the following factors: (a) changing world grain markets as they influence the value of the marginal product, (b) soil conservation, (c) the future price and availability of farm inputs including fossil fuels, fertilizers, chemicals, hired labor, and machinery, (d) technological advances in chemicals, operating practices, and equipment design, (e) reduction of routine jobs such as summerfallow, (f) decreasing a farm's dependence on hired labor, and (g) the individual manager's ability to adapt and implement required production techniques.

Technical and Production Management Factors of Zero-Till

The following is provided only as a brief overview of some of the production relationships involved in zero or minimum till. It is not the purpose of this paper to discuss all of the technical factors in detail. For a more complete review of the production relationships involved, we direct the reader to several references, and suggest he contact agricultural research and extension staff.

1) Soil Management

- a) Soil conservation is of prime concern for the long run benefit of agriculture. Systems of minimum tillage or zero-tillage will reduce both wind and water erosion. While it is difficult to put an economic value on soil erosion control, there is no doubt that a long run economic benefit will be realized.
- b) Soil types - Soil textures appear to have a bearing on the amount of compaction under zero-tillage programs. It appears that compaction is not a problem on medium and light textured soils, particularly in Southern Alberta where freeze-thaw action occurs. Compaction may be a problem on wetter and heavier textured soils. (Vanderpluym).
- c) Soil moisture - yield relationships - A major advantage of minimum and zero-tillage programs is moisture conservation. This is particularly important in areas of limited rainfall and especially so under continuous cropping programs. Other factors being equal, higher yields should be attainable under a zero-tillage program, due to moisture conservation, than will be the case with conventional tillage.

- d) Soil Fertility - Availability of soil nutrients to the plant is influenced by cultivation, soil moisture, and fertilizer placement. Zero or minimum till may require new fertilizer management techniques. The aspect of fertilizer placement should be given particular consideration when contemplating a zero-till program.
- e) Trash Management - Surface residues are greater under minimum and zero-tillage programs than is the case with conventional tillage programs. Under a zero-till program, trash management begins after harvest and requires that the farm manager take steps to ensure even distribution of trash. This may require some investment to modify the straw chopper-spreader on the combine. Also a harrowing operation after harvest may be required to evenly distribute the trash. While cost of straw chopper-spreader modification and harrowing is relatively minor, they should be taken into account when comparing zero-tillage with conventional tillage programs.

2) Machinery Complement and Labor Requirements for Minimum Tillage

Machine complements and labor requirements change as the tillage program changes. When converting from a conventional tillage program to a minimum till program, very few changes will occur in the farmer's machine complement assuming no major changes in the crop rotation. The major input substitution will be a shift to increased use of chemicals and reduced use of tillage implements. Machine investment changes will be highly dependent upon existing equipment at the time the farmer

implements a minimum till program. Possible changes may include:

- i) A larger, more sophisticated sprayer.
- ii) Elimination of a double disc or one way discer.
- iii) Straw chopper-spreader modifications to more evenly distribute trash may be beneficial.
- iv) Seed drill modifications (depending upon level of trash encountered).

Labor requirements per acre under minimum tillage will be similar or slightly reduced from the level under conventional tillage assuming the same crop rotation is followed. The main shift in labor will be from tillage operation to spraying operations. Some labor savings should result from a higher capacity for spraying than for tillage operations.

3) Machine Complement and Labor Requirements for Zero-Tillage

When switching to a zero-tillage program from conventional tillage, several changes in machinery complement will be required. Possible changes (assuming no major change in the crop rotation) required from a typical line of equipment when converting to zero-till include:

- i) A larger, more sophisticated sprayer depending upon present equipment available.
- ii) Straw chopper-spreader modifications.
- iii) Seed drill modifications or the purchase of zero-till drills.
- iv) The elimination of tillage equipment. e.g. cultivators, rod weeders, blades, and discers. Note: Elimination of these implements is dependent upon adoption of a full zero-

tillage program for the entire farm. If zero-till is implemented on part of the acreage (likely a good practice during the learning phase), the reduction in capital costs will not be realized, as these machines will be required for the acreage under conventional tillage.

- v) Reduced tractor size may be accomplished as machines requiring the greatest amount of horsepower are eliminated. Tractor size under zero-till will be dependent upon drill size. Again, reduced tractor size will be not achievable if zero-till is implemented on only a portion of the total acreage. Assuming no major change in cropping pattern, labor requirements per acre will be reduced when switching from conventional tillage to zero-tillage.

The above mentioned changes are primarily concerned with input substitutions (i.e. the input-input relationship). Converting from conventional tillage to zero or minimum tillage combined with crop production intensification requires examination of input-output relationships as well as input substitutions.

4) Machine Complement and Labor Requirements for Zero-Till Under Intensified Cropping

The switch from conventional tillage to zero-tillage will likely result in the farmer changing his cropping pattern. Due to increased moisture conservation, the farm manager may decide to intensify his cropping program. For example, a move from a two-thirds crop rotation to continuous cropping may be possible. If a major shift to a

more intensive cropping program were to take place, then the required machine complement would likely change. It will be necessary to increase drill width to get the additional acres seeded on time. Additional drill width may mean that tractor size cannot be reduced or only reduced slightly from the required size under a conventional tillage program. A more intensive cropping program may also require increased harvesting capacity, a larger swather, or double swath attachment, and a larger combine may be required.

The adoption of both zero-tillage and crop production intensification may actually increase labor requirements. This is especially true for the seeding and harvesting period. Since timing is critical, it is necessary to have adequate machine and labor capacity to complete operations at the correct time. Some technical considerations which have a bearing upon both machinery and labor requirements include:

- a) zero-tilled fields do not dry as quickly as conventional tilled fields.
- b) wind can delay spraying operations under zero-till - this problem does not occur under conventional till.
- c) the application of non-selective herbicides immediately prior to or after seeding competes with the actual seeding operation for labor availability. Under conventional tillage, some tillage operations are normally completed prior to seeding and thus do not compete for labor during seeding.

5) Management and Labor Skills

Management skills are another factor to be considered when con-

templating a zero-tillage program. A zero-tillage program requires a higher level of both labor and management skills than does a conventional tillage program. Timing of zero-tillage operations appears to be very critical. The greater use of sophisticated chemicals requires additional emphasis on efficient and accurate sprayer operation. In the case of hired labor, closer supervision of employees performing the above-mentioned tasks will be required than for employees to perform routine tillage operations.

6) Cash Flow Implications

With both zero and minimum till production systems, the substitution of chemicals for labor and machinery investment will result in increased short run cash costs per acre. This increase in cash flow requirements result in both the continuous and summerfallow rotations. One effect of this increase in cash costs is a decrease in the farm's financial flexibility.

Herbicides must normally be paid for during the cropping season. However, labor on many farms is a non-cash cost (cost in excess over living expenses), and farmers may be able to postpone the purchase of machinery for a year or two during a period of reduced cash flows. In light of this, farm managers considering zero and minimum till should determine the cash flow requirements.

Crop Rotation Flexibility and Marketing

It is important to maintain some flexibility in the cropping program to respond to changing market conditions over time. Maintaining

flexibility in cropping rotations under a zero-tillage program requires the control of volunteer grain from previous crops. Volunteer grain which has emerged prior to the spring application of a non-selective herbicide can be easily controlled. However, volunteer grain which emerges with the crop is much more difficult to control.

Lack of control of volunteer grain will reduce crop rotation flexibility. Flexibility may be further reduced if rapeseed has to be eliminated from the crop rotation due to lack of broad leaf weeds. Flax may be a more appropriate oilseed in a zero-till rotation, as most broad leaf weeds can be controlled by in-crop spraying.

Should admixtures of grain occur due to volunteering, this may result in financial losses due to losses in grade and hence, a lower price. Wheat and barley are difficult, if not impossible, to separate at the port terminals. Thus, volunteer barley in a wheat crop may result in a 1 CWRS wheat being graded 3 CWRS or 3 Utility, depending on percentage of barley present. Beyond approximately 10% barley in the sample, the grain would be graded mixed grain. Grade losses will also occur in the case of volunteer wheat in a barley crop. 1 CW barley may be graded 1 Feed if too much volunteer wheat is present. Barley samples submitted for malting, which would otherwise be accepted, may be rejected by the malt selector if wheat is present in the sample. Barley variety mixtures, due to volunteering of previous barley crops, may result in samples being rejected by the malster. In the case of feed grain, volunteer grain is not a serious problem.

Volunteer rapeseed in cereal crops can be controlled with an application of a broad leaf herbicide. However, volunteer rapeseed in cereal

grains or vice versa is not a serious problem as they can easily be machine separated. Due to ease of separation, the farmer does not suffer grade losses.

The additional production from the implementation of zero-tillage and crop production intensification may result in marketing problems due to insufficient C.W.B. quotas. The additional production may not be sold in time to meet cash flow requirements. The delay in grain sales could be a serious problem. As mentioned previously, cash requirements are much higher under an intensive zero-till program than under a less intensive conventional tillage program.

Economic Analysis of Alternative Tillage and Production Systems

The following portion of this paper will analyze and illustrate the economic and financial effects of zero-till and minimum till production systems. This analysis will consider zero-till from an individual farmer's perspective and will analyze production alternatives including conventional tillage, minimum tillage, and zero-tillage in various rotations within the brown and dark brown soil zones. This analysis will use representative budgets to illustrate the economic advantages of alternate production systems. The following analysis uses available research results. As previously mentioned, these results are subject to some speculation and interpretation. They are also based on the assumption that a farm manager can realize the same production levels as research results.

The authors have not included an analysis of the long run costs and benefits associated with erosion and erosion control. The analysis

is undertaken from a current perspective of an individual farm manager rather than from the long term public costs and benefits of erosion and erosion control. Should this be a consideration for the individual farmer, he could include the estimated benefits as an added return.

When evaluating tillage alternatives, there are two economic relationships to be analyzed. The first economic relationship involves productivity adjustments or input-output relationships. This includes potential yield increases due to soil and moisture conservation from an increased chemical weed control program and also yield increases due to better seed placement. Input-output relationships also include an evaluation of more intensive resource use which would include continuous cropping, where the farm may realize a lower gross margin per acre over a larger number of acres to realize a greater total gross margin. The second economic relationship is that of input substitution. This includes the increased or decreased use of fossil fuels, labor, chemicals, and equipment.

The output or production relationships of conventional and zero-tillage are compared in the following tables. The data is taken from tillage experiments conducted at the Lethbridge Research Station. While the data does give some indication of the yield advantage under zero-tillage, one must exercise care in the interpretation of the data. The data is specific to the soil and climatic conditions experienced at Lethbridge. Also, the data was obtained from plots which were not fertilized.

Yield Advantage of Wheat Raised on
Chemical Zero-Till Summerfallow
Over Mechanical Summerfallow

<u>Year</u>	<u>kg/ha</u>	<u>Bus./acre</u>
1968	304	4.5
1969	(47)	(0.7)
1970	417	6.0
1971	114	1.8
1972	256	3.8
1973	242	3.5
1974	(270)	(4.0)
1975	20	0.3
1976	41	0.6
Average	121	1.3

Source: Adapted from article by Zentner and
Lindwall, Canadian Farm Economics

The yield advantage accruing to the zero-till plots varied from a positive yield increase of 4.5 bushels to a negative 4 bushels when comparing to conventional till plots.

Experimental results indicate the following yield advantages for zero-till wheat production in a continuous cropping situation.

Yield Advantage of Wheat Raised With
Zero-Till Production Over
Continuous Mechanical Tillage

<u>Year</u>	<u>kg/ha</u>	<u>Bus./acre</u>
1968	391	5.7
1969	81	1.2
1970	13	0.2
1971	674	9.9
1972	20	0.3
1973	182	2.7
1974	256	3.8
1975	67	1.0
1976	478	7.0
Average	242	3.5

Source: Adapted from article by Zentner and
Lindwall, Canadian Farm Economics

The yield advantage accruing to the zero-till plots varied between a positive yield increase of 10 bushels per acre, and a positive increase of 0.3 bushel per acre. Should a farm continuously realize the worst possible outcomes, the economics of zero-tillage do not compare favorably with more conventional tillage systems.

These results may not indicate the true potential of a commercial zero-tillage system. The research plots were unfertilized, and thus the relationships between increased soil moisture and fertilizer response have not been evaluated. Also, these results may give an unfair comparison between summerfallow and stubble as beginning soil fertility levels were not necessarily equal.

Preliminary indications from field scale evaluations of zero-till in the dark brown soil zone (Strathmore, Drumheller, and Three Hills areas) by Alberta Agriculture suggest that yields are similar between conventional tilled and zero-tilled plots.

Due to the lack of physical research data, we will first give a review and analysis of the data obtained from unfertilized plots on the dark brown soil zone at the Lethbridge Research Station. Secondly, we will calculate breakeven yields for various zero and minimum tillage systems on the dark brown soil zone. Finally, an analysis of tillage options on the brown soil zone will be conducted.

This analysis will review the costs and returns for spring wheat production and compare seven alternative methods of weed control in three rotations. These alternatives are:

- A. Wheat on mechanical tilled summerfallow (1/2 summerfallow; 1/2 crop rotation).
- B. Zero-till wheat on chemical summerfallow (1/2 summerfallow; 1/2 crop rotation).
- C. Zero-till wheat on combination chemical and mechanical summerfallow (1/2 summerfallow; 1/2 crop rotation).
- D. Zero-till wheat - continuous cropping rotation.
- E. Wheat on mechanically tilled stubble (continuous cropping rotation).
- F. 2/3 rotation: zero-till wheat on stubble and on combination chemical and mechanical summerfallow.
- G. 2/3 rotation: wheat on mechanical tilled summerfallow and on mechanical tilled stubble.

The following table summarizes the per acre yields calculated for the production alternatives considered.

Summary of Spring Wheat Yields

	<u>Per Acre</u>
Dark Brown Soil Zone - Unfertilized Plots	
Alternative A - wheat with mech. tillage on S.F.	27.4
Alternative B - wheat with zero-till on chemical S.F.	29.2
Alternative C - Wheat with zero-till on combination mech. & chem. S.F.	30.9

Alternative D - Stubble wheat with mech. tillage	12.9
Alternative E - Stubble wheat with zero-till	16.4

Source: An Economic Assessment of Dryland Cereal
and Oilseed Cropping Programs in Western
Canada (Zentner et al)

Dark Brown Soil Zone - Fertilized Plots

Alternative A - Wheat with mech. tillage on S.F.	31.0
Alternative D - Stubble wheat with mech. tillage	23.0

Source: An Economic Assessment of Dryland Cereal
and Oilseed Cropping Programs in Western
Canada (Zentner et al)

Brown Soil Zone - Fertilized Wheat Production

Alternative A - Wheat on mech. S.F.	27.0
Alternative D - Stubble wheat with mech. tillage	17.0

Source: An Economic Assessment of Dryland Cereal
and Oilseed Cropping Programs in Western
Canada (Zentner et al)

For calculation of input substitution and subsequent production costs for each rotation, we have included the following typical weed control programs.

Chemical Weed Control Programs
For Various Tillage Options

\$/acre

A. Conventional In-Crop Weed Control following Mechanical
S.F.; 5 mechanical S.F. tillages

1 application of a broad leaf herbicide	\$ 2.50
1 application of a wild oat herbicide on 40% of seeded acreage	4.15
	<hr/>
	\$ 6.65

Chemical Summerfallow

1 application of a non-selective herbicide, tank mixed with a broad leaf herbicide	\$10.50
1 application of a non-selective herbicide	8.00
1 application of a broad leaf herbicide	2.50
1 application of a broad leaf herbicide	2.50
1 application of 2-4-D herbicide	1.50
	<hr/>
	\$25.00

In practice, the type and quantity of herbicide application and costs can vary considerably. Lethbridge Research Station plot experiments have required as few as 2 to as many as 7 applications of a non-selective herbicide.

B. Continuous Cropping Zero-Till, In-Crop Weed Control

1 fall application of 2-4-D herbicide	\$ 1.50
1 application of a non-selective herbicide, tank mixed with a broad leaf herbicide	10.50
1 application of post emergent wild oat herbicide on 2/3 of the seeded acreage <u>1/</u>	7.20
1 application of a broad leaf herbicide	2.50
	<hr/>
	\$21.70

1/ This may be reduced over time as the result of not tilling the soil. Also, spot treatment may be adequate, some years, due to spring application of a non-selective herbicide.

C. In-Crop Weed Control for Zero-Till following Chemical Fallow

1 application of a non-selective herbicide, tank mixed with a broad leaf herbicide	\$10.50
1 application of a post emergent wild oat herbicide on 2/3 of the seeded acreage <u>1/</u>	7.20
1 application of a broad leaf herbicide	2.50
	<hr/>
	\$20.20

D. Conventional In-Crop Weed Control - Continuous Cropping Mechanical Tillage

1 application of a broad leaf herbicide	\$ 2.50
1 application of a wild oat herbicide on 2/3 of the seeded acreage <u>1/</u>	7.20
	<hr/>
	\$ 9.70

E. Combination Chemical and Mechanical Summerfallow

1 fall application of 2-4-D herbicide	\$ 1.50
1 tillage	
1 application of a non-selective herbicide	8.00
1 tillage	
1 application of 2-4-D herbicide	1.50
1 tillage	
	<hr/>
	\$11.00

1/ This may be reduced over time as the result of not tilling the the soil. Also, spot treatment may be adequate, some years, due to spring application of a non-selective herbicide.

The labor and equipment operating costs in the following budgets are calculated from data provided in the Alberta Farm Machinery Cost (Alberta Dept. of Agriculture) publication for the equipment as specified on the equipment investment table. The specific operations for each of the alternative production systems are as follows:

- A. Wheat on Mechanically Tilled Summerfallow.
 - five summerfallow tillage operations using either a rodweeder, cultivator, or blade.
 - two pre-seeding tillages; 1X cultivate and 1X rodweeder.
 - one broad leaf herbicide spraying and a spray application of wild oat herbicide on 40% of seeded acreage.
- B. Zero-Till Wheat Production on Chemical Summerfallow.
 - five spray applications of herbicide for summerfallow.
 - three spray applications of herbicide for in-crop weed control plus a spray application of wild oat herbicide on 2/3 of the seeded acreage.
- C. Zero-Till Wheat on Combination Mechanical Tillage and Chemical Summerfallow.
 - three mechanical tillage operations for summerfallow.
 - three spray applications of herbicide on summerfallow.
 - three spray applications of herbicide for in-crop weed control plus a spray application of wild oat herbicide on 2/3 of the seeded acreage.
- D. Zero-Till Continuous Cropping Wheat Production.
 - three spray applications of herbicide plus a spray application of

wild oat herbicide on 2/3 of the seeded acreage.

E. Wheat Seeded on Mechanical Tilled Stubble.

- three pre-seeding mechanical tillage operations.
- one spray application of broad leaf herbicide plus a spray application of wild oat herbicide on 2/3 of the seeded acreage.

F & G - These 2/3 rotation costs are calculated using the appropriate operations as listed in previous production systems.

Representative Equipment Complements
1,800 Acre Farm at Replacement Value

	50% Cropping			Continuous Cropping			2/3 Rotation	
	A Mech. Tillage	B Zero-Till	C Combination Tillage	D Zero-Till (with zero- till drills)	D1 Zero-Till (using existing drill)	E Mech. Tillage	F & G	
140 H.P. Tractor	41,000	-	-	41,000	41,000	21,000 (U)	41,000	
100 H.P. Tractor	15,000 (U)	28,000	28,000	-	-	-	15,000 (U)	
190 H.P. Tractor	-	-	-	-	-	55,000	-	
60 H.P. Tractor	-	7,000 (U)	7,000 (U)	7,000 (U)	7,000 (U)	7,000 (U)	-	
24' Cultivator	8,000	-	-	-	-	-	8,000	
32' Cultivator	-	-	-	-	-	10,700	-	
36' Rod	5,400	-	-	-	-	5,400	5,400	
24' Harrow	1,800	1,800	1,800	1,800	1,800	-	1,800	
32' Harrow	-	-	-	-	-	2,400	-	
24' Blade	2,100 (U)	-	2,100 (U)	-	-	-	2,100 (U)	
32' Blade	-	-	-	-	-	3,000 (U)	-	
24' Hoe Drills	16,000	16,000	16,000	-	-	-	16,000	
36' Hoe Drills	-	-	-	24,000	-	24,000	-	
36' Zero-Till	-	-	-	-	36,000	-	-	
60' Sprayer	2,600	-	-	-	-	2,600	2,600	
80' Sprayer	-	7,000	7,000	7,000	7,000	-	-	
18' P.T. Swather	4,000	4,000	4,000	-	-	-	4,000	
24' P.T. Swather	-	-	-	5,000	5,000	5,000	-	
S.P. Combine	64,000	64,000	64,000	75,000	75,000	75,000	64,000	
Truck - 3 Ton	13,000	13,000	13,000	13,000	13,000	13,000	13,000	
Auger	3,000	3,000	3,000	3,000	3,000	3,000	3,000	
Storage	18,200	18,200	18,200	23,800	23,800	23,800	18,200	
TOTAL	\$194,100	\$162,000	\$164,100	\$200,600	\$212,600	\$250,900	\$194,100	
ANNUAL OWNER COSTS								
(10 years life, 20% salvage value interest at 13%)	\$ 30,668	\$ 25,596	\$ 25,928	\$ 31,695	\$ 33,591	\$ 39,642	\$ 30,000	

(U) denotes used machine

1/
Labor Requirements
for Alternative
Production Systems

	50% Cropping		Continuous Cropping		2/3 Crop Rotation	
	A Mech. Tillage	B Zero-Till	C Combination Tillage	D Zero-Till	E Mech. Tillage	F G
Total Hours	1,057	676	851	881	1,144	983 1,288
Hours/Seeded Acre	1.17	.75	.95	.49	.64	.82 1.07
Spring-Summer Hours	664	283	458	294	557	460 765
Fall-Winter Hours	393	393	393	587	587	523 523
Value at \$5.00/hour	5,285	3,380	4,255	4,405	5,720	4,915 6,440

1/ Operating time only, does not include overhead and management time.

The following tables provide:

- I. An analysis of Lethbridge Research Station result for unfertilized wheat production in the dark brown soil zone.
- II. A breakeven analysis of alternative means of fertilized spring wheat production in the dark brown soil zone.
- III. A breakeven analysis of alternative means of fertilized spring wheat production in the brown soil zone.

Comparison of Costs and Returns Per Seeded Acre
For Unfertilized Wheat Production Systems
on an 1,800 Acre Commercial Farm
Dark Brown Soil Zone

	50% Cropping			Continuous Cropping		2/3 Crop Rotation	
	A Mech. Tillage	B Zero-Till	C Combination Tillage	D Zero-Till	E Mech. Tillage	F	G
Direct Cash Expenses:							
Seed	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Fertilizer	-	-	-	-	-	-	-
Chemicals & Int. on Operating Capital	7.10	49.75	33.95	23.10	10.35	28.55	8.70
Equip. Oper. & Int. on Operating Capital	12.60	10.80	11.70	6.75	9.50	Costs are combination of (C) and (D)	Costs are combination of (A) and (E)
Property Tax & Misc.	4.60	4.60	4.60	3.00	3.00		
Total Per Acre	30.30	71.15	56.25	38.85	28.85		
TOTAL CASH EXPENSES *	27,270	64,035	50,625	69,930	51,930	57,060	35,490
Yield Per Acre	27.4	29.2	30.9	16.4	12.9		
Gross Margin, Wheat @ \$4/ bu.	71,530	41,165	60,575	48,070	40,870	56,540	61,310
Based on:	24,700 bu.	26,300 bu.	27,800 bu.	29,500 bu.	23,200 bu.	28,400 bu.	24,200 bu.
Labor Expense	5,285	3,380	4,255	4,405	5,720	4,915	6,440
Equipment Ownership	30,668	25,596	25,928	33,591	39,642	30,668	30,668
TOTAL COSTS	63,223	93,011	80,808	107,926	97,292	92,643	75,598
Return to Land & Management:							
Wheat @ \$4.00/bu.	35,577	12,189	30,392	10,074	(4,492)	20,957	24,202
" @ \$5.00/bu.	60,277	38,489	58,192	39,574	18,708	49,357	48,402
" @ \$6.00/bu.	84,977	64,789	85,992	69,074	41,908	77,757	72,602

* This and following sums are calculated for total farm.

The previous table indicates that the zero and minimum till production systems would have to realize an increased yield response as well as the decrease in labor and machinery ownership and operating costs to be competitive with a mechanical tilled 50% summerfallow rotation. Using rotation A as a standard, the alternative production systems would have to realize the following increases in yield or the following decreases in production costs. The estimated breakeven points after Total Costs, including equipment and labor expenses are as follows:

- (1) Rotation B - Chemical summerfallow would have to yield 35.7 bushels per acre, or chemical cost would have to decrease to \$23.75 per acre at \$4.00/bu. wheat (with \$5.00/bu. wheat, breakeven at: yield = 34, or chemicals = \$25.50).
- (2) Rotation C - The combined chemical and mechanical summerfallow would have to yield 32.3 bushels per acre, or chemical cost would have to decrease to \$28.20 per acre at \$4.00/bu. wheat (with \$5.00/bu. wheat, breakeven at: yield = 31.4, or chemicals = \$31.60).
- (3) Rotation D - Continuous zero-till production system would have to yield 20 bushels per acre, or chemical cost would have to decrease to \$8.90 per acre at \$4.00/bu. wheat (with \$5.00/bu. wheat, breakeven at: yield = 18.7, or chemicals = \$11.60).

The previous table illustrates the relatively low cash requirements and hence lower risk position of producing wheat on mechanical summerfallow, compared to the other alternatives examined. With \$4.00/bu. wheat, \$27,270 in direct cash expenses are required to generate a \$71,530 cash margin with mechanical summerfallow, while chemical summerfallow requires \$64,035 in direct cash

expenses to generate a \$41,165 margin, and a continuous zero-till system requires \$69,930 in direct cash expenses to generate a \$48,070 cash margin. If we assume a \$4.00/bu. price for wheat and a 27.4 bushel yield on summerfallow, in order for the alternative rotations to generate an equivalent cash margin, they would have to realize the following yields or chemical costs to breakeven:

- (1) Rotation B - Chemical summerfallow would have to yield 37.6 bushels per acre (compared to research results of 29.2 bushels per acre) or chemical costs would have to decrease to \$16.00 per acre (with \$5.00/bu. wheat, breakeven at: yield = 34.5, chemicals = \$17.80).
- (2) Rotation C - The combined rotation would have to yield 34 bushels per acre (compared to research results of 31 bushels per acre) or chemical costs would have to decrease to \$21.80 per acre (with \$5.00/bu. wheat, breakeven at: yield = 32.6, chemicals = \$25.20).
- (3) Rotation D - The continuous zero-till system would have to yield 19.7 bushels per acre (compared to research results of 16.4 bushels per acre) or chemical costs would have to decrease to \$10.10 per acre (with \$5.00/bu. wheat, breakeven at: yield = 18.5, chemicals = \$12.90).

The above gross margin approach is valid for situations where there are no adjustments to equipment.

We would now like to turn our attention to the breakeven analysis of tillage alternatives on the dark brown soil zone, using fertilizer. The analysis will use the previously identified chemical programs, machinery

complements, and labor requirements. Using this information, we will calculate breakeven yields for the various tillage alternatives compared with tillage and cropping system A. i.e. wheat on mechanical tilled summer-fallow, 1/2:1/2 rotation.

Break Even Analysis per Cropped Acre
for Fertilized Wheat Production Systems
on an 1,800 Acre Commercial Farm
Dark Brown Soil Zone

	50% Cropping		Continuous Cropping		2/3 Crop Rotation	
	A Mech. Tillage	B Zero-Till	C Combination Tillage	D Zero-Till	E Mech. Tillage	F G
<u>Direct Cash Expenses:</u>						
Seed	6.00	6.00 <u>1/</u>	6.00 <u>1/</u>	6.00	6.00	6.00
Fertilizer	7.90	7.90 <u>1/</u>	7.90 <u>1/</u>	13.70	13.70	10.80 <u>2/</u>
Chemicals & Int. on Oper. Capital	7.10	49.75	33.95	23.10	10.35	28.55
Equip. Oper. & Int. on Oper. Capital	12.60	10.80	11.70	6.75	9.50	Costs are combination
Property Tax & Misc.	4.60	4.60	4.60	3.00	3.00	of (C) and (D)
Total Per Acre	38.20	79.05	64.15	52.55	42.55	Costs are combination of (A) and (E)
TOTAL CASH EXPENSES *	34,380	71,145	57,735	94,590	76,590	48,450
Yield Per Acre	[31.0]				[23.0]	
Gross Margin @ \$4/bu.	77,220				89,010	81,150
Based on:	27,900 bu.				41,400 bu.	32,400 bu.
Labor	5,285	3,380	4,255	4,405	5,720	6,440
Equipment Ownership	30,668	25,596	25,928	33,591	39,642	30,668
TOTAL ALL COSTS	70,333	100,121	87,918	132,586	121,952	85,558
Return to Land & Mgte. - Wheat @ \$4/bu.	41,267				43,648	44,042
Breakeven Yields:						
Wheat @ \$4/bu.	31	39.3	35.9	24.2	22.6	
" @ \$5/bu.	31	37.6	34.9	22.4	21.2	
" @ \$6/bu.	31	36.5	34.3	21.3	20.3	

* This and following sums are calculated for total farm.

From the table, we find the following:

- (1) Rotation B - Chemical summerfallow would have to yield an additional 8.3 and 6.6 bushels per acre at \$4.00 and \$5.00 per bushel respectively to breakeven.
- (2) Rotation C - Combined chemical and mechanical fallow would have to yield an additional 4.9 and 3.9 bushels per acre at \$4.00 and \$5.00 per bushel respectively to breakeven.
- (3) Rotation D - Continuous cropping zero-till would have to yield 24.2 and 22.4 bushels per acre at \$4.00 and \$5.00 per bushel respectively to breakeven with Rotation A. The above yields are 78% and 72% of the fallow yields under Rotation A. Conventionally tilled stubble wheat yields are approximately 72% of conventionally tilled fallow wheat yields in the dark brown soil zone. Continuous zero-till can also be compared with Rotation E (continuous cropping wheat on mechanically tilled stubble). Continuous cropping under zero-till would have to yield an additional 1.6 and 1.2 bushels per acre at \$4.00 and \$5.00 per bushel respectively to breakeven with conventionally tilled continuous cropping. Additional moisture conserved under zero-tillage would likely result in this additional yield being achieved. However, the zero-tillage option is slightly higher risk, due to the higher cash costs and the necessity of marketing additional production to generate the required cash flow.

In the dark brown soil zone, Rotation E will provide the highest net income for all of the alternatives (Zentner, et al).

The following breakeven analysis for the brown soil zone indicates that zero- and minimum till wheat production systems will have to realize increased yields in addition to decrease labor and machinery costs to provide the same returns as a 50% summerfallow rotation using mechanical tillage for weed control.

Using Rotation A as a standard, the alternative production systems would have to realize the yields indicated in the following table, or realize lower chemical input costs than those typically being realized.

Breakeven Analysis: Per Cropped Acre
for Fertilized Wheat, Production Systems
on an 1,800 Acre Commercial Farm
Brown Soil Zone

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	50% Cropping		Continuous Cropping			2/3 Rotation	
	A Mech. Tillage	B Zero-Till	C Combination Tillage	D Zero-Till	E Mech. Tillage	F	G
<u>Direct Cash Expenses:</u>							
Seed	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Fertilizer	7.50	8.80	8.80	13.45	6.20	11.10	6.85
Chemicals & Int. On Oper. Capital	7.10	49.75	33.95	23.10	10.35	28.55	8.75
Equip., Oper., & Int. On Oper. Capital	12.60	10.80	11.70	6.75	9.50	Costs are	Costs are
Property Tax & Misc.	4.60	4.60	4.60	3.00	3.00	combination	combination
Total Per Acre	37.80	79.95	65.05	52.30	35.05	of (C) and	of (A) and
						(D)	(E)
TOTAL CASH EXPENSES *	34,020	71,955	58,545	94,140	63,090	64,740	46,710
Yield/Acre	27.0	25.5	27.4	19.7	17.0		
Bushels	24,300	22,950	24,660	35,460	30,600	28,260	26,400
Gross Margin @ \$4.00/bu. wheat	63,180	19,845	40,095	47,700	59,310	48,260	58,890
Less Equipment	30,668	25,596	25,928	33,591	39,642	30,668	30,668
Less Labor	5,285	3,380	4,255	4,405	5,720	4,915	6,440
TOTAL COSTS	69,973	100,931	88,728	132,136	108,452	100,323	83,818
Return to Mgte. & Land:							
Wheat @ \$4/bu.	27,227	(9,131)	9,912	9,704	13,948	12,717	21,782
" @ \$5/bu.	51,527	13,819	34,572	45,164	44,548	40,977	48,182
" @ \$6/bu.	75,827	36,769	59,232	80,624	75,148	69,237	74,582
Breakeven Yield with:							
wheat @ \$4/bu.	27	36	32	22	19		
" @ \$5/bu.	27	34	31	20	18		
" @ \$6/bu.	27	33	25	19	17		

* This and following sums are calculated for total farm.

Zero-till production may provide a practical management tool to be used as an alternative in drought years, or for winter wheat production with benefits including better winter survival.

Based on the previous analysis, zero-till practices are not competitive with conventional tillage systems. The alternative production systems become more competitive as fuel and grain prices increase or chemical inputs and costs decrease. For zero- and minimum till production systems to be competitive, they would have to realize a substantial yield advantage over conventional tillage systems in addition to the fuel, labor, and equipment ownership cost savings. This situation is likely to remain the same until:

- (a) Decreases are realized in the use or cost of chemicals,
- (b) There are increases in the value of grain, energy, labor, or farm equipment, or
- (c) The yield advantage realized by commercial zero-till operation is better than research indicates.

HOW TO ESTABLISH A ZERO-TILL PROGRAM

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ZERO-TILLAGE GUIDELINES (Recropping or continuous cropping rotations)

A. Harvesting and Trash Management

Without good trash distribution, it will be very difficult to obtain effective seed placement and uniform crop stands. For this reason, the decision to try zero-tillage should be made during the summer to allow sufficient time for combine chopper modifications, or for planning other trash practices.

Special trash management practices will normally be required if cereal yields exceed 30 bushels per acre, or if double swathing is practiced. Standard paddle spreaders and choppers generally are not able to spread the straw uniformly over the entire area from which it came. The Agriculture Canada publication, No. 1666, entitled "Improved Spread of Straw During Combining," outlines how modifications can be made to combine straw choppers to improve their effectiveness. Many farmers have made their own modifications to spread the chaff that is deposited directly behind the combine. However, this does not seem to be a problem unless cereal yields exceed 40 bushels to the acre.

Other alternatives for spreading straw include cross-harrowing with light spring-type harrows. This method is most effective soon after harvest and under dry conditions so as not to cause soil disturbance. If yields are high (50 bushels per acre or more), baling of straw may be required, but only if the farmer is continuous-cropping and gets those high yields every year.

Leaving stubble fairly tall (10 to 12 inches), provides excellent snow holding capacity and slows runoff in the spring. Also the canopy or shading effect of tall stubble results in reduced weed growth compared to short stubble or cultivated stubble. Leaving the stubble as long as possible also makes it easier to seed in the spring, as it is usually the loose straw that poses the greatest seeding problems and not the anchored stubble. It may not be possible to leave tall stubble when swathing; however, straight combining will be a practical way of overcoming that problem.

B. Fall Weed Control

Many weeds that are normally a problem in the spring can be effectively and economically controlled after harvest. Stinkweed, flixweed, shepherd's purse and other winter annual weeds germinate soon after harvest, but are often difficult to see in stubble fields. It will be easier and more effective to control these weeds in October with 4-6 oz/A (active) of 2,4-D than it will be the following spring. Such a practice can be recommended even if farmers are not interested in zero-tillage.

Perennial weeds, such as Canada and sow thistle, may pose a problem in some years. These weeds may be sprayed early in the fall, or in the following spring with dicamba or 2,4-D when they are growing rapidly. Also, spot treatment with glyphosate (Roundup) will be effective.

Most other annual weeds or volunteer grain will not be a problem after harvest as they will be killed off by frost. However, in the situation where winter wheat or fall rye is seeded directly into a cereal stubble, it will be necessary (due to the risk of streak mosaic) to control volunteer grain with glyphosate or some other suitable herbicide (details regarding rates and mixtures will be discussed later).

C. Fertilizer Application

For cereal crops grown on fallow, phosphorus can be supplied as ammonium phosphate (11-48-0 or 11-55-0) drilled with the seed as is done in conventional tillage systems. Where moderate amounts of nitrogen are required (up to 40 lb/A or N), nitrogen-phosphate fertilizers such as 23-23-0 and 26-13-0 can be drilled with the seed of cereals. Only 10 lb/A of N can be safely drilled with the seed of oilseed crops (rapeseed, mustard, flax). Note that urea nitrogen is more toxic to germinating seedlings than ammonium nitrate (see the *Alberta Fertilizer Guide* - Table 6 for maximum rates that can be drilled with the seed for the various fertilizers, crops, and soil condition).

In a zero-tillage system, anhydrous ammonia is not a possible alternative. Granular nitrogen fertilizers (such as 34-0-0 or 46-0-0) can be surface applied in late fall or early spring without incorporation. Urea (46-0-0) is more subject to volatilization losses than ammonium nitrate (34-0-0). Warm temperatures, sandy soils, high soil pH (greater than 7.5), and a lack of precipitation favour losses of surface applied urea. Nitrogen solutions (28-0-0 and 32-0-0) contain urea and are therefore similarly subject to volatilization losses. Nitrogen solutions should be drilled in with the seed, rather than sprayed on the soil surface, to avoid excessive contact with the straw mulch. Nitrogen is less subject to loss or immobilization when in direct contact with the soil than when in contact with crop residues.

Fertilizer application rates should be based on soil test levels (sampled in late fall). However, some research has indicated that higher rates of nitrogen will be necessary with zero-tillage because of the greater soil moisture content and slower breakdown of crop residues.

D. Preseeding Weed Control

Usually it will be necessary to control weed growth in the spring just prior to seeding. If winter annual weeds were controlled with a fall or early spring application of 2,4-D, it will be possible to limit preseeding weed control to one timely application of glyphosate for control of most annual weeds and volunteer grain. Seeding as early as possible will make preseeding weed control, as well as in-crop weed control, much easier and more effective.

If existing weed growth prior to seeding consists of only volunteer grain and annual weeds (except wild buckwheat) then glyphosate applied at a rate of 6 oz. (active) in 8-10 gallons of clean water per acre will provide effective control. At this low rate of glyphosate a suitable non-ionic surfactant such as Ag-Surf or Agral 90 (4 pints per 100 gallons of water) must be added to increase the effectiveness of the herbicide. To improve control of annual broadleaf weeds (particularly wild buckwheat) bromoxynil (Torch or similar herbicides) at 4-5 oz/A (active) can be added to the glyphosate mixture. At least a week is required before all vegetation is killed.

Glyphosate is non-selective so it must be applied prior to seeding or just after seeding, but prior to crop emergence. Glyphosate is inactivated when it contacts the soil; therefore, it is very important that clean, soft water is used for spraying and that very little dust is created during the spraying.

E. Seeding

If the crop residue has been uniformly distributed and the weeds adequately controlled, then seeding will not be difficult. Many standard 3-rank hoe drills with an 8 or 9 inch row spacing will operate effectively in undisturbed stubble fields having up to 3,500 pounds per acre of straw and stubble. This is approximately the amount of crop residue produced from a 35 bushel per acre cereal crop in Southern Alberta. The major disadvantage of using hoe drills is that they cause considerable soil disturbances and this can stimulate weed growth in the crop. Also, it is difficult to seed

shallow as desirable with hoe drills and still maintain a uniform crop stand. Shallow seeding is a major benefit of zero-tillage. Optimum seed depth appears to be about 1 to 1 1/2 inches deep, provided the seed is in moist soil. Research has shown that when seeding depth was increased from 2 to 4 inches, wheat yields were reduced by 25 percent.

Because shallow seeding is possible with zero-tillage, some of the heavier double-disc press drills on the market will do an effective job of seed placement. Some farmers have modified double disc drills by installing heavier springs to apply more pressure on the openers, or by mounting cutting coulters ahead of the double-disc openers. The need for special modifications will depend on the specific soil conditions and quantity of trash cover.

It is suggested that the farmer try zero-tillage seeding with his conventional seeding equipment before purchasing any of the new no-till seeders that are now available. Often, he will be pleasantly surprised at how effective his machine can be, provided he has carefully managed his crop residue and effectively controlled weeds.

In the Black soil zone where yields on stubble are usually quite high and large amounts of straw are produced, special straw management practices or specialized seeding equipment will be necessary.

Problems arising with double-or triple-disc seeders are usually that of poor trash cutting and the inability to penetrate compacted wheel-track areas. If the trash is not cut, then the straw will be pressed into the furrow with the seed, resulting in poor soil-to-seed contact and ragged crop stands. Wheel track areas on compacted headlands may have to be cultivated if the freeze-thaw action over winter was insufficient to enable good seed placement.

Under zero-tillage, the more moist conditions on heavier soils may result in seeding problems unless the double-disc openers are equipped with adequate interior and exterior scrapers. Also, adequate packer wheels are essential on heavier soils to ensure furrow closure and proper soil coverage over the soil.

F. Post-Emergent Weed Control in the Crop

In-crop weed control may be more difficult in a zero-tillage system, particularly in the first year or two. Only post-emergent herbicides can be used, so that it may be necessary to spray twice; once for broadleaf weeds and once for wild oats. Weeds will be more of a problem with hoe drills than when double-or triple-disc press drills are used because of the additional soil disturbance which stimulates weed growth. Volunteer grain may often be a problem in crop rotations since there are few, if any, post-emergent herbicides for selective control of cereal grains.

In any case, good weed control in the crop will result in fewer weed problems in the future.

G. General Comments

It is recommended that farmers try zero-tillage on a small scale (50 acres or less) before converting their whole farm to the system and selling all their tillage machinery.

Some of the more successful rotations with zero-tillage have been:

- 1) Winter wheat - barley - rapeseed
- 2) Spring wheat - barley
- 3) Flax - barley
- 4) Continuous barley
- 5) Continuous spring wheat

Since it is very difficult to give a detailed recipe for a zero-tillage system that will work in all locations, the farmer should consult with his local District Agriculturist or Regional Specialists prior to undertaking an extensive zero-tillage program.

H. Chemical Summerfallow

The previous discussion dealt with zero-tillage for a recropping or continuous cropping system. At this time, zero-tillage is not economically feasible in a summerfallow rotation because of the number of herbicide applications necessary throughout the fallow year and prior to seeding. However, in the interest of soil conservation it may be beneficial to replace some tillage operations with the application of a suitable herbicide.

Winter annual weeds like stinkweed, flixweed, and shepherd's purse will be controlled with a fall or early spring application of 2,4-D at 6 oz. per acre, and eliminate or delay the need for cultivation on summerfallow until late May or early June.

Paraquat (Sweep) is now registered for non-selective control of annual grasses and volunteer grain on summerfallow. Paraquat should be applied at 8 oz. per acre in 10 gallons of water when annual grasses are in the 2-4 leaf stage. If broadleaf weeds such as wild buckwheat or other hard-to-kill broadleaf weeds are present at the time of application or between applications of paraquat, apply a recommended broadleaf weed herbicide such as 2,4-D, bromoxynil plus MCPA, dicamba plus 2,4-D, or linuron plus MCPA either as a tank mix with Sweep or as a separate application at the recommended rate of application for each herbicide. As some herbicides recommended above leave residues which may affect growth of some crops seeded in the following year, the farmer should consult labels of these herbicides for restriction in crops which may follow in the rotation.

For minimum tillage fallow on the Brown soils of south eastern Alberta or south western Saskatchewan, apply atrazine at 0.6 pounds per acre in 10 gallons of water per acre to stubble after harvest and prior to freeze-up. Incorporation is not necessary. Do not apply to clay or clay loam soils or to soils with high levels of CaCO_3 at the surface. Normal cultivation or spraying of weed escapes should be started next season as required. Under normal conditions, most annual broadleaved weeds, volunteer grains and wild oats should be controlled until early July. During a dry fallow season, atrazine residues may persist and adversely affect subsequent crops.

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THE EUROPEAN CONCEPT OF DIRECT DRILLING

by
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INTRODUCTION

The main reason for the increase in direct drilling techniques in Europe is economic rather than for reasons of soil and moisture conservation. Until the mid 60's, the primary cultivation for crop establishment was mouldboard ploughing. Since the mid 60's, cultivations have steadily been reducing in severity and in number to the ultimate direct drilling of a crop into undisturbed soil.

The economic background for the increase in direct drilling, particularly in the UK, is illustrated by very substantial increases in fuel costs, reduction in available labour and large increases in machinery and labour costs.

		<u>1970</u>	<u>UK</u>	<u>1979</u>
Fuel	£/gal	0.30		1.20
Labour	£/hour	0.40		1.50
Machinery	£/80 hp tractor	1,800		8,525
Cereals	£/te wheat	30.75		90.0
	barley	28.37		77.0

Against the background of severely increasing costs farmers were forced to cut costs and increase yields wherever possible. The potential to increase yields is not limited by available moisture. The potential is limited by variety, the time available to seed the crop, and the costs of inputs.

In the European Economic Community, prices of cereals are high as a matter of policy (which is another issue) which has encouraged farmers to invest in cereals by increasing inputs of fertilizer, herbicides, fungicides, insecticides and new varieties.

"HOW TO DIRECT DRILL IN EUROPE"

I will confine the "how" techniques to winter cereals and winter oil seed rape as these are the main crops direct drilled in the UK.

<u>'000 has</u>	<u>1974</u>	<u>1977</u>
Winter cereals	35	61
Oil seed rape	15	28
Grass into stubble	14	27
Grass into grass	7	24
Kale and rape	38	27
Catch crop fodder	25	24
Others	<u>8</u>	<u>13</u>
Total	142	204

1. Planning

Fields to be direct drilled should be selected in advance of the time the work is to be done. Direct drilling should not be done as a salvage operation. The farmers ability to increase his management input is essential to successfully direct drill.

2. Field selection

Select a free draining soil with no soil compaction or panning. Avoid fields with a history of water-logging. Localized areas which have been compacted would be corrected by tillage operations.

The previous crop should be a combine harvested crop such as cereals, legumes or oil seed (not a root crop).

Fields with perennial weed problems such as perennial thistle (Cirsium arvense) or couch grass (Agropyron repens) should be avoided or at least treated one year previous to direct drilling a crop. Alternatively glyphosate should be used provided the weeds are controlled. Established Agropyron will become severe under a direct drilling regime.

3. Field preparation

Ideally burn the previous crop residue. A spray of paraquat (0.28 kg/ha) can be used to desiccate green weeds and ensure a complete burn. Baling and removing the straw is the second preferred option. Direct drilling is not recommended into chopped straw. Volunteer grains and annual weeds should be controlled with a spray of paraquat prior to drilling. Drilling can take place immediately.

As a contact spray, paraquat should be sprayed accurately avoiding any missed strips. Apply 0.28 - 1.12 kg/ha paraquat in 200-400 litres of water/hectare. Advisers recommend correct boom height, nozzles, nozzle alignment, water rate, chemical rate, timing and accurate spraying.

4. Fertilizer

On light medium textured soils, the rates of fertilizer need not be increased to achieve equivalent yields with direct drilling. On heavier soils 15-25 kg of extra nitrogen may be required to obtain equivalent yields. Soil pH should be checked for the particular crop and corrected if necessary.

5. Timing of drilling

Direct drilled winter cereals may be slightly more likely to suffer damage from water-logging than traditional sown crops, especially on the heavier soils and if the water-logging occurs before the crop is fully established. Direct drilling of winter oil seed rape should take place by the 12 September and winter cereals by the end of October. As direct drilling reduces the number of operations between harvest and seeding, the crop can be seeded earlier to allow establishment under good growing conditions in October and November.

6. Drilling conditions

Direct drilling should only be carried out when the soil is suitable for conventional drilling, i.e. reasonably dry and friable. Direct drilling should not continue if the soil is wet causing tractor wheel slip or the seed is not being adequately covered by the passage of the drill. Cross harrowing or rolling after drilling may be necessary to cover all the seed.

7. Drilling depth

Cereals should be sown to 2 1/2 - 3 1/2 cm deep, oil seed rape to 1 1/2 cm deep. Checks should be made in the various parts of the field to ensure correct depth of seeding.

8. Prevention of slug damage

Direct drilled crops are prone to slug attack particularly in a wet season where there is a lot of trash on the surface. Apply 16 kg per ha broadcast ICI mini slug pellets (metaldehyde) or drill 8 kg per ha with the seed for preventative action.

9. Direct drilling machinery

- i Bettinson 3D (Melroe 702). Triple disc drill with fertilizer attachment. No press wheel. Tines available. Suitable for all conditions.
- ii International 6-2. Tine drill ideal for cereals. Disturbs the soil more than 25%. Fertilizer attachment. Not suitable for trash conditions.
- iii Jones 519. Seed only cultivator drill. Not suitable for trash conditions.
- iv Moore Unidrill. Single disc seeder with press wheel. Good contour following with individual seed units. Ideal for cereals.
- v Massey 130. Triple disc drill. Ideal for direct drilling.

ADVANTAGES OF DIRECT DRILLING

1. Hours to establish a crop

	<u>Traditional</u>	<u>Minimal cultivations</u>	<u>Direct drilling</u>
Man hours per hectare	5.25	3.75	1.0
Hectares established in a 40 hr week	7.6	10.7	40.0

2. Increased yields due to early drilling

Winter wheat	te/ha
October seeding	5.1
November seeding	4.7
Increase	0.4
Spring barley	
March seeding	4.6
Mid April seeding	3.8
Increase	0.8

3. Increased return from direct drilling

a) Early versus late winter wheat $0.4 \text{ te} \times \text{£}90/\text{te} = \text{£}36/\text{ha}$

b) Winter wheat versus spring barley

5.1 te winter wheat realizes $\text{£}459/\text{ha}$

4.6 te spring barley realizes ($\text{£}77/\text{te}$) $\text{£}354/\text{ha}$

Therefore increased returns to direct drilling winter wheat is $\text{£}105/\text{ha}$.

4. Reduced costs

Labour cost at $\text{£}1.50/\text{hr}$

Costs to establish 100 hectares	$\text{£}/100 \text{ hectares}$
Traditional	789
Minimal cultivation	561
Direct drilling	150
Savings by direct drilling v traditional	639
Savings by direct drilling v min cult	411

5. Costs per hectare to establish a crop
(Wye College Economics Dept 1979)

£/ha	<u>Traditional</u>	<u>Minimal cultivation</u>	<u>Direct drilling</u>
Ploughing	21.0	3 cultivators	19.75
Discing	14.0	2 litres Gramoxone	8.52 3 litres Gramoxone 12.78
Harrowing	4.0	spraying	4.00 spraying 4.00
Seeding	8.65	seeding	8.65 seeding 11.00
		harrowing	4.00 harrowing 4.00
Total	47.65		44.92 31.78*

* £ 37.78/ha if a contractor is used for drilling.

The cost savings in favour of direct drilling are substantial at £ 13.14 to £ 15.87 per hectare respectively.

CONCLUSIONS

European farmers and UK farmers in particular have slowly moved towards an increasing hectarage of direct drilling during the 1970's with three major objectives. Firstly to increase yields and returns from the whole farm, secondly reduce the cost of establishing the crop and lastly reduce the amount of labour required to farm a given farm size.

Farmers however have tended to move slowly towards direct drilling as they "learnt by doing" and discovering how the technique could be used to their own advantage and profit. Cultivations and ploughing are still practiced but direct drilling has given the farmer flexibility to establish a crop quicker, easier and cheaper with an increase in farm profits.

APPENDIX

Average cereal yields 1978

FAO production figures 1978

<u>te/ha</u>	<u>Canada</u>	<u>UK</u>	<u>France</u>	<u>Germany</u>	<u>Australia</u>
Wheat	2.0	5.2	4.9	5.0	1.7
Barley	2.4	4.2	4.1	4.4	1.5

WEED CONTROL IN ZERO TILLAGE

by
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One of the major obstacles which prevented earlier growth of zero tillage as a cropping practice on the prairies was the lack of availability of economically viable herbicides for both annual grass and perennial weed control. Gramoxone was available for annual grass control but at recommended rates was priced too high to be economically viable for use in cereals. Even if Gramoxone had been priced right, it seems doubtful whether the practice of zero tillage would have grown in western Canada since there was no effective means of controlling our two major perennial weeds namely Canada thistle and quackgrass.

In 1978, the Lacombe Research Station initiated a herbicide program aimed at developing economically viable herbicides or herbicide mixtures for weed control in zero tillage. The program was concentrated in 3 main areas, namely:

1. The evaluation of low rates of Roundup or Gramoxone alone and in combination with various wetting agents for annual grass control.
2. A study on low rates of Roundup or Gramoxone in combination with herbicides for broadleaved weed control in order to investigate the possibility of cheap mixtures for broad-spectrum weed control.
3. A investigation of the effects of multiple applications of broadleaved herbicides on crop tolerance i.e. a given herbicide applied prior to crop emergence and again selectively in crop.

Results indicate that rates of both Gramoxone and Roundup as low as 0.21 kg/ha provided consistently excellent annual grass control. Addition of various herbicides for broadleaved weed control such as 2,4-D, MCPA, Torch

Banvel, etc. reduced the rate of onset of annual grass injury with 0.21 kg/ha (acid equivalent) Roundup (and to a lesser extent with 0.21 kg/ha Gramoxone) but did not reduce the final degree of grass kill with the mixtures; see, for example, Table 3. The 0.21 kg/ha rate of Roundup was the minimum rate which would consistently kill annual grasses. To further enhance this rate a non-ionic surfactant (see later) should be added to the spray solution (0.5% v/v). To obtain annual broadleaved weed control, a broadleaved herbicide should be chosen based on the broadleaved weed spectrum. Also since 0.21 kg/ha Roundup is the minimum effective rate, it is essential that clean, soft water be used, that the sprayer be accurately calibrated and that spray application be uniform. There is no room for error. All of the spray applications in these studies were in 100 l/ha of water when the grasses were in the 4-5 leaf stage (early tilling).

Table 3. Influence of Torch on the rate of onset of annual grass injury with Roundup.

TREATMENT	Rate hg/ha	<u>Percent Topgrowth Kill</u>		
		OATS	BARLEY	WHEAT
<u>5 Days After Treatment</u>				
Check	--	0	0	0
Roundup	0.21	83	83	96
Roundup + Torch	0.21 + 0.35	73	75	90
<u>18 Days After Treatment</u>				
Check	--	0	0	0
Roundup	0.21	98	98	98
Roundup + Torch	0.21 + 0.35	96	98	100

Further research has shown that with rates of Roundup, lower than 0.21 kg/ha there is permanent loss of Roundup activity on annual grasses in mixtures with herbicides for broadleaved weed control and that the antagonism experienced with these mixtures occurs in the tank rather than in the plant. This antagonism can be overcome by split applications.

The influence of various non-ionic wetting agents on the degree of annual grass kill with low rates of Roundup and Gramoxone were tested. Renex 36 reduced Gramoxone activity on annual grasses whereas the other wetting agents (listed below with Roundup) tested had no effect. Wetters could be divided into 3 groups according to how they influenced Roundup activity. Those that enhanced herbicidal activity included Agral 90, Tween 20, Triton X-100 and X-77; those that reduced activity included Renex 36, Cettowet plus, aplus 411F and Dupont WK; and those that did not influence activity included Amway, Wex, Triton X-114 and Triton X-A special.

In a series of tests which included most of the commonly used herbicides for broadleaved weed control, Banvel was the only product which injured both barley and wheat when applied prior to seeding, and again selectively in the crop.

ZERO TILLAGE - IS IT THE SOLUTION

M.K. Price
Weed Control Branch
Edmonton, Alberta

Many of the advantages of zero-till are well known and widely quoted. Less erosion, labour saving, energy saving and possible reductions in annual weeds. In a recent Plant Industry Newsletter I outlined some of the possible disadvantages which we have yet to confront. I will only recap them here since you no doubt have had the opportunity to read them.

- (a) Vulnerability to developments in the chemical world -
 - Bans
 - Plant shutdowns
 - Price increases
 - Other unforeseen - use your imagination
- (b) Cash requirement - does not allow for belt tightening in hard times.
- (c) Weed control problems

I would like to spend more time on this latter point. It is true that chemicals are generally available to control most common weeds, however the important weeds will likely change under zero-till. Timing is also a problem. The need for critical timing of application for most herbicides will place the farmer even more at the mercy of weather. There is no easy or cheap way to retrieve a situation with herbicides if weeds get out of hand.

We had an example this spring where a farmer on a zero-tillage program wanted a spray recommendation to rectify an impossible situation - our recommendation was till it. Where the same effect can be achieved by tillage as by spraying and where tillage is cheaper, why not use it. This is now minimum till - not zero till but who cares. Let's do what works. Zero till or minimum till as the circumstances dictate. This is simply an extension of current recommendations. If it doesn't require working don't work it. Don't worry about seedbed preparation, it has been proven already that seedbed preparation is not essential, but for patches of perennial weeds what is the harm of breaking zero-till to give them hell with the cultivator? It beats \$30.00 plus per acre for Round-up. Fall weed control and straw spreading are an extension of current good practices. If conditions next spring look good for no-till seeding; do it. If not, work it once. It won't hurt anything.

Of course this approach is messy for researchers because they can't separate out the effect of pure zero-till. They cannot compare the expedient approach with any standard since there is no rigid procedure. This is the researchers problem not the farmers.

Many things a farmer does because intuition tells him it is right. Research provides the tools in this case the herbicides the farmer adapts them to his system. This is the art rather than science of farming.

If we learn anything from the current world situation it should be not to become dependent on one system. For this reason development of zero-till as an alternative must proceed but don't trade in the cultivator just yet.

The use of soil incorporated herbicides has increased the level of tillage in the recent past because of the extra working for no other reason than to mix the herbicide. This must be dangerous, it must increase fuel usage and aggravate erosion. Perhaps new developments in post emergent applications, in aircraft application will reverse the trend, making fewer operations necessary.

The weed problem in central and Northern Alberta is tremendous. It has not been licked with tillage and herbicides. I doubt it will be dealt with by eliminating tillage.

I imagine many speakers have already warned. Don't attempt zero till except on the cleanest of land. I wish to repeat that warning.

REPORT ON THE WESTERN MINIMUM TILLAGE COMMITTEE AND PROVINCIAL PROTOCOLS

By
Ferrin Leavitt
Weed Control Branch

Western Canada Zero Till Committee

Purpose: To review Western Canada research needs in zero till and submit recommendations for research accomplishment to the Federal Research Co-ordinator, and to allow an exchange of zero till information on a Western Canada level.

Membership: The committee consists of several farmer representatives and provincial extension and research representatives in the area of soil, plant science, entomology and disease.

Committee Recommendations for Research or Extension:

1. That each province be responsible for the preparation and updating of an extension information kit on zero tillage.

Status: All of provinces except British Columbia have compiled an informaton manual on zero tillage.

2. Update the crop similation model to accommodate additional data including fertilizer inputs.

Status: The present model can accommodate the brown, dark brown and black soil zones. Most of the work has been done on the brown soil zone. If approved, a Ph.D. thesis will be undertaken on updating the minimum tillage model.

3. That Agriculture Canada increase support relative to the development of control measures for volunteer crops.

Status: The University of Manitoba is undertaking work this year. Further research studies will be recommended at Regina and Indian Head stations. Note: Target and possibly Lontrel D show promise for the control of volunteer flax in cereals. A compound from BASF provided excellent control of wheat and barley in flax in trials at Carman this year.

4. That Agriculture Canada increase support relative to the development of effective marking systems to be used for stubble spraying.

Status: Pami in Lethbridge will write a report on comparative studies with respect to adga and spot markers. It may be possible to replace the silver marker dye with orange or red dye for marking in stubbles.

It is suggested that engineers at Saskatoon and possibly in Alberta be encouraged to submit project proposals on possible research into more effective marker systems.

5. To continue to support the development of effective straw and chaff spreading equipment for combines.

Status: Work is being done at Swift Current and Saskatoon. It was proposed that Agriculture Canada support further contracts in this area.

6. To assist in the development of a drill that will provide adequate penetration and suitable seed placement with a minimum of soil disturbance when seeding directly into high residue stubble fields.

Status: Modification work going on in Alberta, Manitoba and Saskatchewan. Additional contracts may be recommended.

7. Another area of soils research required in zero tillage is soil physics. Physical properties of soil tend to be most permanent and the most difficult to alter since soil physical properties are likely to be different under zero tillage than under conventional tillage. It is important to make quantitative measurements of soil properties under zero till.

Status: It is recommended that more support be given to research stations where temperature or moisture may be a problem. Beaverlodge is working on a method of predicting soil temperature based on air temperature and snow cover. It is further recommended that work on soil temperature and moisture be conducted at Saskatoon, Melfort, Beaverlodge and Lethbridge.

It was noted that zero tilled fields are warmer in the winter as a result of the insulating effect of crop residue. Preliminary tests in Manitoba and observations in Alberta indicate that winter wheat will survive much better on zero till fields. This year stands on zero till in Manitoba were excellent compared with a 50 - 100% stand reduction in tilled fields.

8. In the prairie provinces, the concept of zero tillage is often closely associated with the challenges concerning continuous cropping practices. Research on zero till also implies the knowledge of continuous cropping. In some cases zero tillage may accentuate some of the problems encountered with continuous cropping such as moisture availability, and should also consider other deficiencies. Further research support for work at federal stations and universities is required to answer questions concerning the alteration of

soil structure and temperature under zero till practices on different soil types. The effects of this cropping practices on the microbiology, erosion and salinity status needs to be further investigated.

Status: Emphasis will be placed on a research related to fertilizer application. The committee will also encourage a inter-disciplinary approach to zero tillage research at stations in order to pinpoint areas requiring further research.

It was noted that red turnip beetle, fungus, and common root rot are likely to be much more prevalent under zero till conditions.

Provincial Protocols on Zero Till

1. In-Service Training:

Purpose: To provide the latest information on zero tillage to extension personnel who are receiving requests for zero till information from farmers in their area.

2. Information Dispersion:

Purpose: The purpose of this protocol was to disperse current information (not recommendations) on zero till by mail to farmers practicing zero till on their farms.

Approximately 75 farmers are now on our mailing list as submitted by District Agriculturist and Agricultural Fieldmen. The following information has been mailed to these farmers:

- a. Current information from industry manufacturing herbicides which can be used effectively under zero till.
- b. Federal bulletin publication no. 1666, "Improve Spread of Straw During Combining".
- c. A guide to zero till farming prepared by the weed control branch from current information.

3. Data Accumulation:

Those farmers registered by District Agriculturists and Agricultural Fieldmen under the data accumulation protocols have been contacted and weed data has been accumulated this year. A weed survey approach is being used and will provide information on those weeds that are increasing and those that are decreasing under zero till. A number of farmers under this protocol have found it necessary to use tillage in order to keep weeds under control.

ZERO TILLAGE ACTIVITIES AND IMPRESSIONS

by
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ACTIVITIES

1. An "ad hoc" committee across three disciplines (weeds, soils, ag. engineering) representing three agencies (Agriculture Canada, University of Alberta, Alberta Agriculture) has been in existence for approximately two years. The basic function of this committee was communication amongst interested individuals in the agencies and disciplines. This ad hoc committee assisted the Alberta representatives on the Western Canada Committee on Minimum Tillage formed in mid-1978.
2. The Alberta Heritage Trust Fund provides funds for agricultural research through the "Farming for the Future" program. Three projects were approved involving weed control (A. O'Sullivan, Lacombe), agricultural engineering (M. Green, Airdrie), and off-station zero till tests (W. Lindwall, Lethbridge).

IMPRESSIONS

Zero tillage is a concept rather than a single technique as some may wish to believe. Therefore it is very difficult to demonstrate zero-tillage on a farm by following a set of rules or guidelines as conditions (weed, climate, soil) continually change and inter-act with one another causing a new or different set of conditions at each growth stage of the crop. There are three major areas in zero till:

- i) Weed control - weed populations change from day to day, field to field depending upon the original infestation, chemical control, and weather. Cultivation usually establishes a new time base line either through partial or complete control or by placing the weed seed in an ideal germination condition. With no cultivation, complete kill is important, so the proper herbicide and its timed application is most critical. Therefore demonstrations set up without almost constant observation are difficult to establish or provide meaningful results.
- ii) Seeding and fertilizing - these change from field to field, and generally affected by weather conditions and previous crop type and yield.
- iii) Straw management - this is really the beginning of the annual cycle in zero tillage because evenly spread straw is required for adequate depth controlled seeding.

Our present attitude on zero tillage is one of tests or trials on a few acres in order to develop some expertise and confidence of all aspects. Some requirements of a zero till farmer are:

- i) a high level of management ability, i.e. intuition, initiative, and innovative ability,
- ii) an excellent knowledge of chemical weed control practices and equipment to go along with it,
- iii) an ability to take risks (a few extra dollars to cover emergency control), and
- iv) have extra time to make regular field observations to control weeds early.

We expect that zero till fields require approximately three to five years before a "new equilibrium" is reached as weed populations and the soils chemical and physical characteristics take on the changed environment as a result of no tillage.

APPLICATION IN ALBERTA

Zero tillage will most likely succeed where some additional moisture is conserved and chemical weed control costs are minimal. Zero or minimum tillage also has advantages where wind erosion is a hazard.

N.L.C. - B.N.C.



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